12-10-99

A

U.S. Express Mail Label No. EL531624234US

Docket No. 230980.0213

jc690 U.S. PTO
12/09/99

jc525 U.S. PTO
09/456665
12/09/99

FOLEY & LARDNER
2029 Century Park East – Suite 3500
Los Angeles, CA 90067-3021

TO: Assistant Commissioner for Patents
Box Patent Application
Washington D.C. 20231

UTILITY PATENT APPLICATION TRANSMITTAL UNDER 37 C.F.R. 1.53(b)

Transmitted herewith for filing is the patent application of:

INVENTOR(S): Tadao Kikumoto

TITLE: METHOD AND SYSTEM FOR WAVEFORM COMPRESSION AND EXPANSION

In connection with this application, the following are enclosed:

APPLICATION ELEMENTS:

X Specification (including Abstract): 44 pages
X Claims: 25
X Informal Drawings: 14 Sheets
Power of Attorney By Assignee and Exclusion of Inventor Under Rule 37 C.F.R. § 3.71
X Declaration and Power of Attorney for Patent Application (Japanese Language Declaration)
X Unsigned
_ Executed (original or copy)
_ Copy from a prior application (37 CFR 1.63(d))
(relates to continuation/divisional boxes completed) - NOTE: Box below

ACCOMPANYING APPLICATION PARTS:

_ Assignment Papers (cover sheet & document(s))
Revocation and Power of Attorney
_ Information Disclosure Statement(IDS) with PTO-1449.
_ Copies of IDS Citations
_ Preliminary Amendment
X Check in the amount of $1006.00 for filing fee.
X Certificate of Mailing By Express Mail
X Return Receipt Postcard (MPEP 503)
_ Small Entity Statement(s)
_ Statement filed in prior application, status still proper and desired.
_ Certified Copy of Priority Document(s) with Claim of Priority (if foreign priority is claimed).

CONTINUING APPLICATION, check appropriate box and supply the requisite information:

_ Continuation _ Divisional _ Continuation-in-part (CIP) of prior application Serial No._.
_ Amend the specification by inserting before the first line the following sentence: --This application is a_ continuation, _ divisional or _ continuation-in-part of application Serial No._, filed _.--

CORRESPONDENCE ADDRESS:
Please address all future correspondence to:
Ted R. Rittmaster at the Foley & Lardner address noted above.
Telephone: (310) 277-2223
Fax Number: (310) 557-8475

FEE CALCULATIONS: (Small entity fees indicated in parentheses.)

(1) For	(2) Number Filed	(3) Number Extra	(4) Rate	(5) Basic Fee $760. ($380.)
Total Claims	25 - 20 = 5	5	x $18 (x $9)	90.00
Independent Claims	5 - 3 = 2	2	x $78 (x $39)	156.00
Multiple Dependent Claims: 0			$260 ($130)	0.
Assignment Recording Fee per property			$40	0.
Surcharge Under 37 C.F.R. 1.16(e)			$130 ($65)	0.
			TOTAL FEE:	$1006.00

METHOD OF PAYMENT:
A check in the amount of the above TOTAL FEE is attached. If payment by check is NOT enclosed, it is requested that the Patent and Trademark Office advise the undersigned of the period of time within which to file the TOTAL FEE. If payment is enclosed, this amount is believed to be correct; however, the Commissioner is hereby authorized to charge any deficiency or credit any overpayment to Deposit Account No. 19-0741.

Respectfully submitted,

December 9, 1999
Date

Glenn M. Kubota
Reg. No. 44,197

U.S. Express Mail Label No. EL531624234US

Docket No. 230980.0213

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

Tadao Kikumoto

Serial No.: Unassigned

Filed: Concurrently herewith

Attorney Docket No. 230980.0213

Group Art Unit: Unassigned

Examiner: Unassigned

For: METHOD AND SYSTEM FOR WAVEFORM COMPRESSION AND EXPANSION

CERTIFICATE OF MAILING BY EXPRESS MAIL

Assistant Commissioner for Patents
Box Patent Application
Washington, D.C. 20231

Assistant Commissioner:

I hereby certify that the following paper(s) and/or fee along with any attachments referred to or identified as being attached or enclosed are being deposited with the United States Postal Service as Express Mail (Express Mail Label No. EL531624234US) under 37 C.F.R. § 1.10 on the date of deposit shown below with sufficient postage and in an envelope addressed to: Assistant Commissioner for Patents, Box Patent Application, Washington D.C. 20231.

1. Utility Application Transmittal Sheet
2. Specification, Claims and Abstract: 44 Pages
3. Informal Drawings: 14 sheets
4. Declaration and Power of Attorney for Patent Application (Japanese Language Declaration, unsigned)
5. Check No. for $1006.00 for filing fee
6. Return Postcard

Respectfully submitted,

December 9, 1999
Date

Glenn M. Kubota
Reg. No. 44,197

Foley & Lardner
2029 Century Park East, 35th Floor
Los Angeles, CA 90067-3021
Telephone: 310-277-2223
Facsimile: 310-557-8475

PATENT APPLICATION IN THE U.S. PATENT AND TRADEMARK OFFICE

for

METHOD AND SYSTEM FOR WAVEFORM COMPRESSION AND EXPANSION

by

Tadao Kikumoto

Background of the Invention

1. Field of the Invention

The invention relates to a waveform compression and expansion apparatus with which a waveform is compressed or expanded in the direction of the temporal axis.

2. Description of Related Art

For some time, the changing of the pitch of musical tones etc. by transforming the pitch of the signal that expresses the waveform of the musical tones etc., the so-called pitch shifter, has been known. However, when the pitch of a signal that expresses the waveform of a phrase, which has a length to the degree that the tempo of the musical tones is known, is transformed by the pitch shifter, there is a problem in that the tempo of the musical tones is also changed and there has been a desire for a system with which only the pitch is changed without changing the tempo of the musical tones. Conversely, a system with which the tempo is changed while the pitch of the musical tones is preserved has also been desired.

As a system that responds to these demands, a waveform compression and expansion apparatus with which the waveform of the musical tones etc. is compressed or expanded in the direction of the temporal axis independently of the alteration of the pitch has been proposed.

However, a multiple number of compression and expansion formats can be considered as the format with which the waveform will be compressed or expanded. In

addition, with regard to the waveform that expresses the sound, there are various kinds of waveforms such as periodic waveforms, aperiodic waveforms, intermittent waveforms and continuous waveforms and, a compression and expansion processing format can be considered that appropriately compresses or expands the waveform in the direction of the temporal axis in conformance with the type of waveform. That is to say, for a given waveform, when the compression and expansion are carried out with a format that is appropriate to the variety of that waveform, the tonal quality of the sound that is expressed by the waveform following compression and expansion will be satisfactory. However, in the case where, for a given waveform, the compression and expansion is done with a format that is not appropriate to the variety of that waveform, the tonal quality of the sound that is expressed by the waveform following compression and expansion will be poor.

However, in general, the waveforms of musical tones etc. are waveforms in which various kinds of waveforms have been mixed together. Because of this, no matter which compression and expansion processing format is employed, there is a problem in that it is likely that the tonal quality of the musical tones etc. that is expressed by the waveform following the compression and expansion of the waveform of the musical tones etc. will be poor.

Summary of the Disclosure

The present invention, taking into account the above mentioned circumstances, was made with the object of presenting a waveform compression and expansion apparatus with which the tonal quality of the musical tones etc. that is expressed by the waveform following the compression and expansion of the waveform of the musical tones etc. will be satisfactory.

The first waveform compression and expansion apparatus of the present invention that achieves the above mentioned object is characterized in that it comprises a compression and expansion means with which a multiple number of band divided waveforms that comprise the original waveform which has been divided into waveform components of a multiple number of frequency bands are apportioned to at least two kinds of compression and expansion formats and all of these multiple number of band divided waveforms are formed into a multiple number of compressed and expanded waveforms by means of compression or expansion in the direction

of the temporal axis an identical amount only and a superimposing means in which, by means of the superimposing of the multiple number of compressed and expanded waveforms that have been formed by the compression and expansion means, a compressed and expanded waveform that has been compressed or expanded in the direction of the temporal axis from the above mentioned original waveform is formed.

With a waveform that expresses musical tones etc. in which various kinds of waveforms have been mixed together, in general, due to the division into waveform components of a multiple number of frequency bands, there are many cases in which the separation of the waveform types can be done.

Since, in accordance with the first waveform compression and expansion apparatus of the present invention, the multiple number of band divided waveforms that comprise the waveform components of a multiple number of frequencies that the original waveform has been divided into are apportioned to at least two kinds of compression and expansion formats and compressed or expanded in the direction of the temporal axis, even in those cases where a waveform that expresses musical tones etc. is used as the original waveform, due to the fact that the compression and expansion are carried out by compression and expansion formats that are appropriate to each of the various kinds of band divided waveforms, it is possible to form compressed and expanded waveforms that express musical tones etc. having satisfactory tonal quality.

In addition, in general, when a single kind of compression and expansion format is employed and compression and expansion are done, it is likely that periodic noise similar to flutter or a vibrato effect will be produced. This effect is the result of the looping of cycles. However, in accordance with the first waveform compression and expansion apparatus of the present invention, each compression and expansion format with which each band divided waveform is compressed and expanded is selected so that the phase of each compressed and expanded waveform becomes a phase that is mutually different and, by this means, it is possible to prevent the flutter or vibrato effect.

With the first waveform compression and expansion apparatus of the present invention, it is preferable that the above mentioned compression and expansion means execute

compression and expansion processing with a processing period that is as long as the band divided waveform which possesses the waveform component of the low frequency band in the above mentioned multiple number of band divided waveforms and, by this means, forms the compressed and expanded waveforms that correspond to said band divided waveforms.

In general, those waveform components that are as long as the waveform components of the low frequency band are waveform components that are important to the human sense of hearing. Because of that, the implementation of advanced compression and expansion processing demands a processing time that is as long as the waveform component of the low frequency band. In addition, in general, even if the frequency of the processing that has a period as long as the waveform component of the low frequency band is reduced, the tonal quality can be maintained.

Because of this, by means of the implementation of compression and expansion processing with a processing period that is as long as the band divided waveform which possesses the waveform component of the low frequency band, it is possible to produce a temporal margin for the implementation of advanced compression and expansion processing with the waveform component of the low frequency band and all of the waveform components can be compressed and expanded with satisfactory efficiency.

The second waveform compression and expansion apparatus of the present invention that achieves the above mentioned object is characterized in that it comprises a compression and expansion means in which a multiple number of compression and expansion processing formats that are mutually different are employed and the waveforms are compressed or expanded in the direction of the temporal axis and a processing format specification means in which the compression and expansion formats of each of the temporally divided waveforms are specified so that the compression and expansion processing of the multiple number of time divided waveforms that comprise the original waveform which has been divided into a multiple number of temporal regions are allotted to the above-mentioned multiple number of compression and expansion formats and the compression and expansion means employs the compression and expansion format that has been specified by the processing format

specification means for each temporally divided waveform and carries out compression and expansion processing.

With a waveform that expresses musical tones etc. in which various kinds of waveforms are mixed together, there are many cases where the varieties of waveforms can be separated by a division into a multiple number of temporal regions.

Since in accordance with the second waveform compression and expansion apparatus of the present invention, the multiple number of temporally divided waveforms that comprise the original waveform which has been divided into a multiple number of temporal regions are allotted to a multiple number of varieties of compression and expansion formats and compressed or expanded in the direction of the temporal axis, even in those cases where a waveform that expresses musical tones etc. has been used as the original waveform, due to the fact that compressions and expansions are carried out with the compression and expansion processing formats that are appropriate to each of the various kinds of waveforms, it is possible to form compressed and expanded waveforms that express the musical tones etc. with satisfactory tonal quality.

As has been discussed above, in accordance with the waveform compression and expansion apparatus of the present invention, the tonal quality of the musical tones etc. which the waveform expresses following the compression and expansion of the waveforms of the musical tones etc. is satisfactory.

Brief Description of the Drawings

FIG. 1 is an explanatory drawing of the first compression and expansion processing format according to an embodiment of the present invention.

FIG. 2 is an explanatory drawing of the second compression and expansion processing format according to an embodiment of the present invention.

FIG. 3 is an explanatory drawing of the third compression and expansion processing format according to an embodiment of the present invention.

FIG. 4 is a hardware structural diagram of the first preferred embodiment of the waveform compression and expansion apparatus of the present invention.

FIG. 5 is a diagram that shows one example of a band divided waveform according to an embodiment of the present invention.

FIG. 6 is a diagram that shows the frequency bands of the waveform components that each of the band divided waveforms possesses according to an embodiment of the present invention.

FIG. 7 is an equivalent circuit diagram to explain the operation with which the compressed and expanded original waveform is formed in accordance with the first preferred embodiment.

FIG. 8 is a flowchart that shows the operation of the first preferred embodiment.

FIG. 9 is a diagram that shows one example of a time divided waveform according to an embodiment of the present invention.

FIG. 10 is an equivalent circuit diagram to explain the operation with which the compressed and expanded original waveform is formed in accordance with the second preferred embodiment.

FIG. 11 is a diagram that shows another example of a time divided waveform which is different from the example of a time divided waveform that is shown in FIG. 9 according to an embodiment of the present invention.

FIG. 12 is the first part of a flowchart that shows the operation of the second preferred embodiment.

FIG. 13 is the second part of a flowchart that shows the operation of the second preferred embodiment.

FIG. 14 is the third part of a flowchart that shows the operation of the second preferred embodiment.

Detailed Description of Preferred Embodiments

Below, in providing an explanation of the preferred embodiments of the present invention, first an explanation will be given of examples of compression and expansion processing formats and, following that, an explanation will be given regarding the preferred embodiments of the waveform compression and expansion apparatus of the present invention.

In the following explanation, there are cases where no differentiation is made between the concept of a waveform and the concept of the waveform data that express that waveform.

In addition, in the following explanations of each of the compression and expansion processing formats, the waveform prior to compression and expansion, whether it is the original waveform or a frequency band-divided waveform, is called the "original waveform" and the waveform following compression and expansion is called the "compressed and expanded waveform." Furthermore, an explanation will be given here regarding the case where the compressed and expanded waveform in which the original waveform has been expanded in the direction of the temporal axis is formed having the same pitch as the pitch of the original waveform.

FIG. 1 is an explanatory drawing of the first compression and expansion processing format.

With the first compression and expansion format, as is explained in detail below, an opening and starting address is set on the original waveform that delimits each pitch or cycle of the original waveform, and pitches or cycles from the original waveform is read out alternately by two processing groups. A processed waveform is formed by each of the processing groups based on the original waveform that has been read out and all of the processed waveforms that have been formed are superimposed on each other forming a compressed and expanded waveform. When the original waveform is read out, the waveform is compressed or expanded in the direction of the temporal axis by the carrying out of jump reading (skipping of cycles) or repetitive read-out (repetition of cycles).

The original waveform is shown in the topmost stage of FIG. 1(a). The horizontal axis of FIG. 1(a) shows the address of the waveform data that express the original waveform and, together with this, also corresponds to the temporal axis of the original waveform. In addition, in FIG. 1(a), the opening and starting addresses csa1, ..., csa7, which delimit the original waveform one pitch or cycle at a time, are shown. The opening and starting addresses may delimit cycles at zero-crossings of the original waveform, or alternatively, energy

peaks of the original waveform. Zero crossings are preferably used for aperiodic waveforms, while energy peaks are preferably used for periodic waveforms.

In FIG. 1(b), the time points t_0, ..., t_7, which are arranged on the temporal axis at time intervals that correspond to the reproduced pitch or cycle of the compressed and expanded waveform, are shown and in the specific example of FIG. 1, for each time point t_0, ..., t_7, the waveform data for the amount of approximately two pitches of the original waveform are read out. However, it should be noted that generally, the amount of pitch or cycle data read out at each time point is dependent on the how much the original waveform is being compressed or expanded. In addition, in FIG. 1(b), the position information elements that indicate the positions on the original waveform, PP(0), ..., PP(7), are shown and the positions that are indicated by each of the position information elements PP(0), ..., PP(7) are the objects of the read-outs that are started at each time point t_0, ..., t_7. Furthermore, the positions on the original waveform that are indicated by each of the position information elements PP(0), ..., PP(7) are indicated by each arrow F_0, ..., F_6 that points from FIG. 1(b) to FIG. 1(a) with the time points t_0, ..., t_7 as their starting points and each arrow F_0, ..., F_6 is shown in a position that is further left in the figure that the opening and starting addresses csa1, ..., csa7.

Here, the intervals of each of the opening and starting addresses csa1, ..., csa7 that are shown in FIG. 1(a) and the intervals of each of the time points t_0, ..., t_6 that are shown in FIG. 1(b) are mutually identical and, as was discussed above, form compressed and expanded waveforms that have pitches which are the same as the pitches of the original waveform. In addition, the positions on the original waveform that are indicated by each of the position information areas PP(1), ..., PP(6) are shown in a position that is more to the left in the figure than each of the opening and starting addresses csa2, ..., csa7 and, because of this, as will be discussed later, a repetitive read-out of the waveform data is carried out forming, as has been discussed above, the compressed and expanded waveform of the original waveform that has been expanded in the direction of the temporal axis.

The triangular waveforms that are shown by the dotted lines in FIG. 1(c) and FIG. 1(d) indicate the window or envelope that is used by the first processing group and that is used by the second processing group respectively and the waveforms that are shown by the solid

lines if FIG. 1(c) and FIG. 1(d) indicate each of the processed waveforms. The window or envelope produces a waveshaping function that limits the amplitude of the processed waveform. Because the envelope may not coincide with zero crossings of the original waveform in other embodiments, the triangular envelope of FIG. 1 forces the amplitude of the waveform data to be zero at the start and end of each envelope, which essentially creates a zero crossing at the start and end of each envelope. Having a zero crossing at the boundary of each cycle helps to minimize discontinuities in the compressed waveform and resultant sound when the cycles are looped. In the specific example of FIG. 1, the opening and starting addresses are shown in FIG. 1(c) and FIG. 1(d), and these opening and starting addresses correspond to the beginnings of the waveform data for the amount of two pitches that have been read out by each of the processing groups. Each processed waveform is mated and formed with the envelopes that are shown in FIG. 1(c) and FIG. 1(d) and the waveform data that have been read out by each of the processing groups and these processed waveforms are superimposed forming the compressed and expanded waveform.

The read-out of the waveform data by the first processing group is started at the time point t_0. Since, as is shown in FIG. 1(a) and FIG. 1(b), the position information element PP(0) indicates the position of the opening and starting address csa1, as is shown in FIG. 1(c), the waveform data for the amount of two pitches is read out from the opening and starting address csa1. Thus, for FIG. 1(c), between time points t_0 and t_2, original waveform data between opening and starting addresses csa1 and csa2 are read out twice. Again, it should be noted that generally, the amount of pitch or cycle data read out at each time point is dependent on the how much the original waveform is being compressed or expanded.

The read-out of the waveform data by the second processing group is started at the time point t_1. As is shown in FIG. 1(a) and FIG. 1(b), the position information element PP(1) indicates the position of the interval between the opening and starting address csa1 and the opening and starting address csa2. Because of this, this position is included among the read-out objects and, as is shown in FIG. 1(d), the waveform data for the amount of two pitches are read out from the opening and starting address csa1. Thus, for FIG. 1(b), between time points

t_1 and t_3, original waveform data between opening and starting addresses csa1 and csa2 are read out twice. As a result, a repetitive read-out of the waveform data is carried out.

In the same manner as that described above, for the time points t_2, ..., t_5, the read-out of the waveform data for the amount of two pitches is started from the opening and starting addresses csa2, ..., csa5.

For the time point t_6, as is shown in FIG. 1(c), the read-out of the waveform data by the first processing group for the amount of two pitches is started from the opening and starting address csa5 and a repetitive read-out of the waveform data is carried out.

As a result of this kind of repetitive read-out, the amount of the time interval To of the original waveform that is shown in FIG. 1(a) is expanded in the direction of the temporal axis and the compressed and expanded waveform is formed for the amount of the time interval Ts that is shown in FIG. 1(d).

FIG. 2 is an explanatory drawing of the second compression and expansion processing format.

With the second compression and expansion format, as will be explained in detail below, portions of waveform portions are read out alternately by the two processing groups from the original waveform and these waveform portions are made the beginnings of the read-out starting positions that advance at a fixed speed on the original waveform. Each processed waveform is produced by each of the processing groups based on the waveform portions that have been read out and all of the processed waveforms that have been formed are superimposed forming a compressed and expanded waveform. The pitch of the compressed and expanded waveform is determined in conformance with the read-out speed of the waveform portions and the rate of compression or the rate of expansion in the direction of the temporal axis of the waveform is determined in conformance with the speed of advance of the read-out starting position.

In FIG. 2(a), the original waveform is shown and the horizontal axis of FIG. 2(a), together with indicating the address of the waveform data that expresses the original waveform, corresponds to the temporal axis of the original waveform.

In FIG. 2(b), the time points t_0, ..., t_6, at which each of the processing groups start the read-out of the waveform portions, are shown and the position information elements PP(0), ..., PP(5) that indicate the read-out starting positions for each of the time points t_0, ..., t_5 are shown. In addition, the positions on the original waveform that are indicated by each of the position information elements PP(0), ..., PP(5) are indicated by the arrows F_0, ..., F_5 that point toward FIG. 2(a) with each of the time points t_0, ..., t_5 as the starting points and each of the arrows F_0, ..., F_5 indicates a position that is equivalent to a time point that is more in the past than each of the time points t_0, ..., t_5.

In FIG. 2(c) and FIG. 2(d), the waveform portions H_0, ..., H_5 that have been read out alternately by the first processing group and the second processing group are shown and each waveform portion is made the beginning of each of the read-out starting positions that are indicated by each of the position information elements PP(0), ..., PP(5).

In FIG. 2(e) and FIG. 2(f), the windows or envelopes that are used by the first processing group and the second processing group are shown and these windows and the waveform portions that are indicated by the codes that are annexed to each of the windows are mated forming each of the processed waveforms. The mating is a waveshaping function applied to the waveform portions by the windows. As described earlier, the triangular envelope creates zero crossings which minimize discontinuities when the waveform portions are looped. These processed waveforms are superimposed and the compressed and expanded waveform is formed.

Here, the speed of the read-out of each of the waveform portions H_0, ..., H_5 is identical to the recording speed of the original waveform. Because of this, the pitches of each of the waveform portions H_0, ..., H_5 following the read-outs by the first processing group and the second processing group that are shown in FIG. 2(c) and FIG. 2(d) are in agreement with the pitches that are possessed by each of the waveform portions H_0, ..., H_5 prior to the read-outs from the original waveform and, as discussed above, a compressed and expanded waveform having pitches that are identical to pitches of the original waveform is formed. In addition, since the speed of advance of the read-out starting position is slower than the recording speed and, as is shown in FIG. 1(a) and FIG. 1(b), each read-out starting position that corresponds to each of the time points t_1, ..., t_5 is equivalent to a starting point that is more in the past than each of the

time points t_1, ..., t_5, for the reading out of the entire original waveform, it is necessary that the time be longer than the time for the recording of the entire original waveform. As a result, the amount of the time interval To of the original waveform that is shown in FIG. 2(a) has been extended in the direction of the temporal axis and the time interval portion of the compressed and extended waveform that is shown in FIG. 2(f) is formed.

FIG. 3 is an explanatory drawing of the third compression and expansion processing format.

With the third compression and expansion processing format, as is explained in detail below, even if a cyclic reproduction of the original waveform is done, delimiting mark addresses for each waveform segment in which the reproduced sound is natural are set on the original waveform. The mark addresses designate zero –crossings of the original waveform, or alternatively, energy peaks of cycles in the original waveform. Zero-crossings are preferably used for aperiodic waveforms, while energy peaks are preferably used for periodic waveforms. Each of the waveform segments is read out in order and the compressed and expanded waveform is formed by their reproduction. The pitch of the compressed and expanded waveform is determined in conformance with the read-out speed of the waveform segments and, by the carrying out of the jump reading (skipping of waveform segments) or the reread-out of the waveform segments (repetition of waveform segments), the compression or expansion of the waveform is done.

In FIG. 3(a), the original waveform and the mark addresses m_1, ..., m_7 that have been set on the original waveform are shown and the horizontal axis of FIG. 1(a), together with indicating the addresses of the waveform data that express the original waveform, corresponds to the temporal axis of the original waveform.

In FIG. 3(b), the time points t_0, ..., t_5 at which the read-outs of each of the waveform segments start and each of the position information elements PP(0), ..., PP(4) that indicate the positions on the original waveform are shown and each position information element PP(0), ..., PP(4) becomes an object of the read-outs that are started for each time point t_0, ..., t_5. In addition, the positions on the original waveform that are indicated by each of the position information elements PP(0), ..., PP(4) are indicated by each of the arrows F_0, ..., F_5

that point toward FIG. 3(a) with each of the time points t_0, ..., t_5 as the starting points. The arrow F_0 indicates the position of the mark address m_1 and the arrow F_1 indicates the position of the interval between the mark address m_1 and the mark address m_2. In addition, the arrow F_2 indicates the position of the interval between the mark address m_2 and the mark address m_3, the arrow F_3 indicates the position of the interval between the mark address m_3 and the mark address m_4 and the arrow F_4 indicates the position of the interval between the mark address m_4 and the mark address m_5.

In FIG. 3(c), the waveform segments that have been read out are shown and the mark addresses that correspond to the beginnings of each of the waveform segments are also shown.

As is shown in FIG. 3(a) and FIG. 3(b), since at the time point t_0, the position information element PP(0) indicates the position of the mark address m_1, as is shown in FIG. 3(c), the read-out of the waveform segment is started with the mark address m_1 as the beginning. Here, the read-out speed of the waveform interval is identical to the recording speed of the original waveform. Because of this, the pitch of the waveform segment that is shown in FIG. 3(c) is identical to the pitch of the original waveform that is shown in FIG. 3(a) and a compressed and expanded waveform is produced that has the same pitch as the pitch of the original waveform.

At the time point t_1 where the entire waveform segment, the read-out of which was begun at the time point t_0, has been read out, the position information element PP(1) indicates the position of the interval between the mark address m_1 and the mark address m_2. This position is included as an object of the read-out and, as is shown in FIG. 3(c), the reread-out of the waveform segment is begun with the mark address m_1 as the beginning.

After that, the read-out of the waveform segments is begun at each time point t_2, t_3 and t_4 with the mark addresses m_2, m_3 and m_4 respectively as the beginnings.

At the time point t_5 where the entire waveform segment, the read-out of which was begun at the time point t_4, has been read out, the position information element PP(5) indicates the position of the interval between the mark address m_4 and the mark address m_5.

The reread-out of the waveform segment is begun with the mark address m_4 as the beginning so that this position is included as an object of the read-out.

As a result of this kind of reread-out having been carried out, the original waveform for the amount of the time interval To that is shown in FIG. 3(a) is expanded in the direction of the temporal axis and the compressed and expanded waveform for the amount of the time interval Ts that is shown in FIG. 3(c) is formed.

Above, an explanation was given regarding the expansion operations for three kinds of compression and expansion formats and, when the speed of advance of the position information elements for each of the formats is made faster, the read-out of the original waveform data becomes a jump reading (skipping of cycles or waveform segments). As a result, a compressed and expanded waveform is formed in which the original waveform has been compressed in the direction of the temporal axis.

In the above manner, it is possible to change the compression and expansion and their amount by setting the speed of advance of the position information element.

As described above, an explanation was given regarding three kinds of compression and expansion processing formats but the compression and expansion processing formats for the present invention are not limited to the formats for which explanations were given above and, as long as it is a format with which the waveform is compressed or expanded in the direction of the temporal axis, it may be used. In addition, with regard to the "multiple number of compression and expansion processing formats" and the "at least two kinds of compression and expansion processing formats" in the present invention, in addition to two kinds of compression and expansion formats from among the three kinds of compression and expansion formats for which explanations were given as described above being included, it also includes, for example, arbitrarily using the second compression and expansion processing format of the above mentioned explanation and a multiple number of compression and expansion formats with which the time intervals for the read-out of the waveform data portions are mutually different.

With the above, the explanations regarding examples of compression and expansion formats have been completed and an explanation concerning the preferred embodiments of the present invention will be given below.

The first preferred embodiment of the waveform compression and expansion apparatus of the present invention is a system in which all of the multiple number of band divided waveforms that comprise the waveform components of the multiple number of frequency bands into which the original waveform that expresses the musical tones etc. is divided are compressed or expanded an identical amount only in the direction of the temporal axis and each of the compressed and expanded waveforms is formed. The compressed and expanded original waveform from the original waveform that has been compressed and expanded in the direction of the temporal axis is formed by the superimposing of these compressed and expanded waveforms.

FIG. 4 is a hardware structural diagram of the first preferred embodiment of the waveform compression and expansion apparatus of the present invention.

In the waveform compression and expansion apparatus 10, the CPU 11 and the DSP 12 are provided. The DSP 12 is controlled by the CPU 11 and, as will be discussed later, the compressed and expanded waveform is formed by the DSP 12.

In addition, in the waveform compression and expansion apparatus 10, the hard disk 13, the ROM 14, the MIDI interface 15, the first RAM 16 and the operators 17 are provided. On the hard disk 13, the waveform data of the original waveform that expresses the musical tones etc. is stored and, based on these waveform data, the band divided waveforms are formed by the DSP 12. In the ROM 14, the program that represents the operation of the CPU 11 and the DSP 12 is stored and the program that represents the operation of the DSP 12 is transmitted to the DSP 12 by the CPU 11. MIDI signals are input from outside via the MIDI interface 15 and the data that indicate the pitch that corresponds to this MIDI signal as well as the sound generation timing that corresponds to this MIDI signal are sent to the DSP 12 by the CPU 11. The first RAM 16 is used as working memory by the CPU 11 and the operators 17 are operated by the user of the waveform compression and expansion apparatus 10 in order to furnish instructions to the CPU 11.

In addition, in this waveform compression and expansion apparatus 10, the D/A converter 18 and the second RAM 19 are provided. In the second RAM 19, the divided waveform data that indicate the band divided waveforms are stored and compressed and expanded waveforms as well as the compressed and expanded original waveform are formed by the DSP 12 based on the divided waveform data. The D/A converter 18 changes the digital signal that expresses the compressed and expanded original waveform which has been formed by the DSP 12 into an analog signal.

FIG. 5 is a diagram that shows one example of a band divided waveform.

The original waveform is divided into three frequency band waveform components in the first preferred embodiment.

An example of an original waveform is shown in FIG. 5(a). This waveform is a waveform that represents a continuous sound of which the sound of a violin etc. is representative.

In FIG. 5(b), the first band divided waveform which possesses the waveform component of the frequency band from among the three frequency bands that has the highest frequency is shown and this first divided band waveform is an intermittent waveform.

In FIG. 5(c), the second band divided waveform which possesses the waveform component of the frequency band from among the three frequency bands that has the median frequency is shown and in FIG. 5(d), the third band divided waveform which possesses the waveform component of the frequency band from among the three frequency bands that has the lowest frequency is shown.

In addition to the waveform that is shown in FIG. 5(a), the one musical instrument sound that was discussed previously is not the only one that can be given as an example of a waveform for which compression and expansion by means of the waveform compression and expansion means of the present invention is desirable and there are waveforms that express the performance sounds of various kinds of musical instruments and performance states including those of a combined performance by a multiple number of musical instruments.

FIG. 6 is a diagram that shows the frequency bands of the waveform components that each of the band divided waveforms possesses.

In this preferred embodiment, the waveform data that express the original waveform are sampled at a sampling frequency fs and waveform components that have a frequency of fs/2 or less are included in the original waveform. The frequency band B_1 of the waveform component that possesses the first band divided waveform is a frequency band that is fs/2 or less and fs/4 or more and the sampling frequency f_1 of the waveform data that express the first band divided waveform is equal to the sampling frequency fs. The frequency band B_2 of the waveform component that possesses the second band divided waveform is a frequency band that is fs/4 or less and fs/8 or more and the sampling frequency f_2 of the waveform data that express the first band divided waveform is one half the frequency of the sampling frequency fs. The frequency band of the waveform component that possesses the third band divided waveform is a frequency band that is fs/8 or less and the sampling frequency f_3 of the waveform data that express the first band divided waveform is one quarter the frequency of the sampling frequency fs.

FIG. 7 is an equivalent circuit diagram to explain the operation with which the compressed and expanded original waveform is formed in accordance with the first preferred embodiment.

The three waveform memories 191, 192 and 193 are shown in this equivalent circuit diagram and here, the divided waveform data that express the first, second and third band divided waveforms that are shown in FIG. 5 are respectively stored in the waveform memories 191, 192 and 193. The three waveform memories 191, 192 and 193 represent the role of the second RAM 19 that is shown in FIG. 4.

In addition, the three compression and expansion means 121, 122 and 123 are shown in this equivalent circuit diagram and the compression and expansion means that is described in the present invention comprises these three compression and expansion means 121, 122 and 123. The first, second and third band divided waveforms are respectively compressed or expanded in the direction of the temporal axis by the compression and expansion means 121, 122 and 123 and the output ao, output bo and output c are respectively produced. As has been

discussed above, the divided waveform data that express the first, second and third band divided waveforms which are shown in FIG. 5 are stored in the three waveform memories 191, 192 and 193 and the type of waveform of the first band divided waveform is different from those of the second and third band divided waveforms. Because of this, in this preferred embodiment, the second compression and expansion format that was discussed above is employed for the compression and expansion means 121 and the third compression and expansion format that was described above is employed for the compression and expansion means 122 and 123. The compression and expansion processing by each of the compression and expansion means 121, 122 and 123 is carried out with a processing period that corresponds respectively to the sampling frequencies f_1, f_2 and f_3. The pitch data that indicate the rate of change of the pitches of each of the band divided waveforms, the compression and expansion data that indicate the amount of compression and expansion of the waveforms and the reproduction direction data that designate the timing of the start of sound generation and the timing of the termination of sound generation are input into each of the compression and expansion means 121, 122 and 123. The pitch data, the compression and expansion data and the reproduction direction data are produced by the CPU 11 in conformance with the MIDI signals that have been input via the MIDI interface 15 that is shown in FIG. 4 and sent to the DSP 12.

In addition, the first low pass filter 124, the second low pass filter 125 and the addition circuits 126 and 127 are shown in this equivalent circuit diagram and the superimposing means that is described in the present invention comprises these. Furthermore, the compression and expansion means 121, 122 and 123, the low pass filters 124 and 125 and the addition circuits 126 and 127 express the working of the DSP 12 that is shown in FIG. 4.

The second low pass filter 125 is a filter with which the waveform components that have a frequency of $f_3/2$ (equals fs/8) or above are eliminated. In the second low pass filter 125, by means of the input of the output c from the third compression and expansion means 123, which is equivalent to the compressed and expanded waveform that is a compression and expansion of the third band divided waveform, sampling from the sampling frequency f_3 (equals fs/4) to the sampling frequency f_2 (equals fs/2), so-called oversampling, is executed and the output cf, which has the sampling frequency f_2, is produced. Following that, the output cf is

added by the addition circuit 127 to the output bo from the second compression and expansion means 122, which is equivalent to the compressed and expanded waveform that is a compression and expansion of the second band divided waveform, and the output b is produced.

The first low pass filter 124 is a filter with which the waveform components that have a frequency of $f_2/2$ (equals fs/4) or above are eliminated. In the first low pass filter 124, by means of the input of the output b, oversampling from the sampling frequency f_2 (equals fs/2) to the sampling frequency f_1 (equals fs) is executed and the output bf, which has the sampling frequency f_1, is produced. Following that, the output bf is added by the addition circuit 126 to the output ao from the first compression and expansion means 121, which is equivalent to the compressed and expanded waveform that is a compression and expansion of the first band divided waveform, and the output a is produced.

FIG. 8 is a flowchart that shows the operation of the first preferred embodiment.

This flowchart is the flowchart for the execution in the DSP 12 that is shown in FIG. 4 of an operation that is equivalent to the operation for which an explanation was given using FIG. 7.

The operation that is expressed by this flowchart is repetitively executed at the sampling frequency f_1 (equals fs). Step S103, which will be explained below, is repetitively executed at the sampling frequency f_3 (equals fs/4) and Step S106 through Step S108, which will be explained below, are repetitively executed at the sampling frequency f_2 (equals fs/2).

When the operation that is expressed by this flowchart is begun, first, in Step S101, the pitch data P and the compression and expansion data TR are input from the CPU.

Following that, in Step S102 through Step S104, the output c is produced.

First it proceeds to Step S102 and a determination is made as to whether or not the value of the control variable N with which the counter for the repetitions of the operations that are indicated by this flowchart is advanced is a multiple of 4. If it is determined that the value of the variable N is a multiple of 4, it proceeds to Step S103, the third compression and expansion processing that is shown in FIG. 3 is executed with the waveform data that express the third band divided waveform and the output c is produced. When a determination is made

that the value of the variable N is not a multiple of 4, it proceeds to Step S104 and the value of the output c is made "0."

Following that, in Step S105 through Step S109, the output b is produced.

First it proceeds to Step S105 and a determination is made as to whether or not the value of the control variable N is a multiple of 2. If it is determined that the value of the variable N is a multiple of 2, it proceeds to Step S106, filter processing is executed with the output c and the output cf is produced. Next it proceeds to Step S107, the third compression and expansion processing is executed with the waveform data that express the second band divided waveform based on the pitch data P and the compression and expansion data TR and the output bo is produced. Next it proceeds to Step S108, output bo and output cf are added and the output b is produced. In the case where it has been determined in Step S105 that the value of the variable N is not a multiple of 2, it proceeds to Step S109 and the value of the output b is made "0."

Following that, the output a is produced in Step S110 through S112.

First it proceeds to Step S110, filter processing is executed with the output b and the output bf is produced. Next it proceeds to Step S111, the second compression and expansion processing that is shown in FIG. 2 is executed with the waveform data that express the first band divided waveform based on the pitch data P and the compression and expansion data TR and the output ao is produced. Next it proceeds to Step S112, the output ao and the output bf are added and the output a is produced.

Following that, it proceeds to Step S113 and the output a is output through the D/A converter 18 that is shown in FIG. 4.

Following that, in Step S114 through Step S116, it advances so that the value of the control variable N changes cyclicly in a range of a value of "0" through a value of "3" and terminates.

The second preferred embodiment of the waveform compression and expansion apparatus of the present invention is a system in which a multiple number of time divided waveforms which comprise an original waveform that expresses a musical tone etc. that has been divided into a multiple number of temporal regions are apportioned to a multiple number

compression and expansion processing formats and form compressed or expanded waveforms by means of compression or expansion in the direction of the temporal axis.

Since the hardware configuration of the second preferred embodiment is the same as the hardware configuration of the first preferred embodiment a duplicative explanation will be omitted.

FIG. 9 is a diagram that shows one example of a time divided waveform.

In FIG. 9(a), an example of an original waveform is shown and three kinds of waveform, P_1, P_2 and P_3, are contained in this original waveform. These waveforms P_1, P_2 and P_3 represent three sounds that have mutually different sound generation timings and pitches. These waveforms, P_1, P_2 and P_3, are each an example of a time divided waveform of the present invention. With regard to the compression and expansion processing formats with which these waveforms, P_1, P_2 and P_3 are compressed and expanded, the third compression and expansion processing format that was discussed above is suitable for the waveforms P_1 and P_2 and the first compression and expansion processing format that was discussed above is suitable for the waveform P_3. As will be discussed later, these compression and expansion processing formats are employed in this preferred embodiment.

In FIG. 9(b), the windows W_1, W_2 and W_3 that delimit the temporal regions are shown. The window W_1 delimits the temporal region from the time point a01 to the time point a02, the window W_2 delimits the temporal region from the time point a11 to the time point a12 and the window W_3 delimits the temporal region from the time point a21 to the time point a22.

In this preferred embodiment, the original waveform is divided in advance into a multiple number of band divided waveforms that each possess a multiple number of frequency band waveform components and compression and expansion processing that employs each of the compression and expansion formats is executed with the multiple number of band divided waveforms. In addition, the portions that correspond to the waveforms P_1, P_2 and P_3 are separated from the waveforms following the compression and expansion by the windows W_1, W_2 and W_3 that are shown in FIG. 9(b) and the specification of the compression and expansion processing formats is, in essence, done by this separation.

In FIG. 9(c), the band divided waveform that possesses the waveform component of the highest frequency band from among the multiple number of band divided waveforms is shown and the waveform P_1 from among the three kinds of waveforms P_1, P_2 and P_3 is primarily contained in this band divided waveform.

In FIG. 9(d), the band divided waveform that possesses the waveform component of the median frequency band from among the multiple number of band divided waveforms is shown and the waveform P_2 from among the three kinds of waveforms P_1, P_2 and P_3 is primarily contained in this band divided waveform.

In FIG. 9(e), the band divided waveform that possesses the waveform component of the lowest frequency band from among the multiple number of band divided waveforms is shown and the waveform P_3 from among the three kinds of waveforms P_1, P_2 and P_3 is primarily contained in this band divided waveform.

Actually, in FIG. 9(c), FIG. 9(d) and FIG. 9(e), only the portions that correspond to each of the waveforms P_1, P_2 and P_3 of each of the band divided waveforms are shown and these portions are separated by the windows W_1, W_2 and W_3 that are shown in FIG. 9(b). The horizontal axes of FIG. 9(c), FIG. 9(d) and FIG. 9(e) each represent a multiple number of band divided waveforms and, together with indicating the addresses of the first waveform data, the second waveform data and the third waveform data, they correspond to the temporal axes of each of the band divided waveforms. In this preferred embodiment, each band divided waveform is sampled at a sampling frequency that corresponds to the frequency band of the waveform component that each band divided waveform possesses and compression and expansion processing is executed with a processing period that corresponds to each sampling frequency. In this manner, each band divided waveform is compressed and expanded with good efficiency.

FIG. 10 is an equivalent circuit diagram to explain the operation with which the compressed and expanded original waveform is formed in accordance with the second preferred embodiment.

In this equivalent circuit, the three waveform memories 21, 22 and 23 are shown and the band divided waveforms that are shown in FIG. 9(c), FIG. 9(d) and FIG. 9(e) are

respectively stored in these three waveform memories 21, 22 and 23. The three waveform memories 21, 22 and 23 represent the role of the second RAM 19 that is shown in FIG. 4.

In addition, the three compression and expansion means 31, 32 and 33 are shown in this equivalent circuit diagram and the compression and expansion means that is described in the present invention comprises these three compression and expansion means 31, 32 and 33. Each of the band divided waveforms that have been stored in each of the waveform memories 21, 22 and 23 is compressed or expanded in the direction of the temporal axis by the compression and expansion means 31, 32 and 33. In this preferred embodiment, the third compression and expansion processing format that has been discussed above is employed with the compression and expansion means 31 and 32 and the first compression and expansion processing format that has been discussed above is employed with the compression and expansion means 33. In addition, the compression and expansion processing by means of each of the compression and expansion means 31, 32 and 33 is carried out with a processing period that corresponds to the sampling frequencies f_1, f_2 and f_3 of each of the band divided waveforms and, here, the sampling frequencies f_1, f_2 and f_3 are in a relationship where $f_3 = f_2/2 = f_1/4$. In addition, pitch data, compression and expansion data and reproduction direction data are input to each of the compression and expansion means 32, 32 and 33. The pitch data indicate the rate of change of the pitch of each band divided waveform, the compression and expansion data indicate the amount of compression and expansion of the waveform and the reproduction direction data indicate the timing with which the sound generation is started and the timing with which the sound generation is terminated. In addition, the pitch data, the compression and expansion data and the reproduction direction data correspond to the MIDI signals that are input via the MIDI interface 15 shown in FIG. 4. They are produced by the CPU 11 and sent to the DSP 12.

In addition, in this equivalent circuit, the level control means 40 and the multiplication circuits 51, 52 and 53 are shown. Each of the processing format specification means in the present invention comprise these. The levels of the windows W_1, W_2 and W_3 are controlled by the level control means 40 and the signals that indicate the levels are input to the multiplication circuits 51, 52 and 53. The levels of each of the windows W_1, W_2 and W_3 and the

outputs of each of the compression and expansion means 31, 32 and 33 are mated and, by this means, from the outputs of each of the compression and expansion means 31, 32 and 33, the portions that correspond to each of the waveforms P_1, P_2 and P_3 that are shown in FIG. 5(a) are separated and the outputs ao, bo and c are produced. The specification of the compression and expansion processing formats that are employed in each of the compression and expansion means 31, 32 and 33 as the formats for the compression and expansion of each of the waveforms P_1, P_2 and P3 is, in essence, done by means of this separation.

In addition, in this equivalent circuit, the first low pass filter 61, the second low pass filter 62 and the addition circuits 71 and 72 are shown. The compression and expansion means 31, 32 and 33, the multiplication circuits 51, 52 and 53, the low pass filters 61 and 62 and the addition circuits 71 and 72 represent the action of the DSP 12 that is shown in FIG. 4.

The output c is input to the second low pass filter 62 and so-called oversampling is executed with the output c by the second low pass filter 62 from the sampling frequency f_3 to the sampling frequency f_2. The output cf is produced with the sampling frequency of f_2. Following that, the output cf is added to the output bo by the addition circuit 72 and the output b is produced.

The output b is input to the first low pass filter and oversampling is executed with the output b from the sampling frequency f_2 to the sampling frequency f_1. The output bf is produced with the sampling frequency of f_1. Following that, the output bf is added to the output ao by the addition circuit 71 and the output a, which corresponds to the waveform that is the original waveform which has been compressed and expanded, is produced.

Since, in the manner that has been discussed above, the compression and expansion processing formats that are suitable to the type of waveform are employed in each of the compression and expansion means 31, 32 and 33, the sound quality of the sound that the output a represents is satisfactory.

FIG. 11 is a diagram that shows another example of a time divided waveform which is different from the example of a time divided waveform that is shown in FIG. 9.

In Fig 11(a), another example of an original waveform, which is different from the example of an original waveform that is shown in FIG. 9(a), is shown and the frequency of

this original waveform changes continuously from a high frequency to a low frequency together with the passage of time. Actually, only the envelope of the original waveform is shown in FIG. 11(a) and the waveform itself is omitted from the drawing. The example of FIG. 11 is typically encountered during the attack portion of a musical sound such as a drum, voice, or musical instrument. In preferred embodiments, the initial attack as designated by window W1 is not looped in the compression or expansion processing format, but subsequent temporal regions designated by windows W_2 and W_3 may be looped.

The windows W_1, W_2 and W_3 are shown in FIG. 11(B) and, the same as the windows W_1, W_2 and W_3 that are shown in FIG. 9(b), the window W_1 delimits the temporal region from the time point a01 to the time point a02, the window W_2 delimits the temporal region from the time point a11 to the time point a12 and the window W_3 delimits the temporal region from the time point a21 to the time point a22. However, differing from FIG. 9(b), in FIG. 11(b), the time point a11 is a time point that is prior to the time point a02 and, between the time point a11 and the time point a02, the window W_1 and the window W_2 produce so-called cross fading. In the same manner, the time point a21 is a time point that is prior to the time point a12 and, between the time point a21 and the time point a12, the window W_2 and the window W_3 produce cross fading.

In the same manner as in FIG. 9(c), FIG. 9(d) and FIG. 9(e), in FIG. 11(c), FIG. 11(d) and FIG. 11(e), a multiple number of band divided waveforms are shown that comprise the multiple number of waveform components of the frequency bands into which the original waveform has been divided. However, as has been discussed above, since the frequency of the original waveform changes together with the passage of time, here, the envelopes of the portions in which each of the band divided waveforms are primarily contained from among the original waveforms that are shown in FIG. 7(a) have been shown. These portions are examples of divided waveforms of the present invention and these portions are separated from the original waveform by the windows W_1, W_2 and W_3 that are shown in FIG. 7(b).

Each of the band divided waveforms is sampled with each of the sampling frequencies f_1, f_2 and f_3 and the first waveform data, the second waveform data and the third

waveform data are stored in each of the waveform memories 21, 22 and 23 that are shown in FIG. 10.

FIG. 12, FIG. 13 and FIG. 14 are flowcharts that show the operation of the second preferred embodiment.

This flowchart is a flowchart for the purpose of running the operation using FIG. 11 and an equivalent operation in the DSP 12 that is shown in FIG. 4

The program flow continues from Step S206 or Step S207 of FIG. 12 to Step S208 of FIG. 13, and the program flow also continues from Step S213 or Step S215 of FIG. 13 to Step S216 of FIG. 14.

The operation that is expressed by this flowchart is executed repeatedly with the sampling frequency f_1. Step S204 through Step S206, which will be explained below, are executed repeatedly with the sampling frequency f_3 and Step S209 through Step S214, which will be explained below, are executed repeatedly with the sampling frequency f_2.

When the operation that is expressed by this flowchart is started, first, in Step S201, the pitch data P and the compression and expansion data TR are input from the CPU, it proceeds to Step S202 and the variable AT, which indicates the time point on the temporal axis that is shown in FIG. 9(b) and FIG. 11(b), is advanced by the compression and expansion data TR.

Following that, the output c is calculated in Step S203 through Step S207.

First it proceeds to Step S203 and a determination is made as to whether or not the value of the control variable N, with which the counter for the repetitions of the operations that are indicated by this flowchart is advanced, is a multiple of 4. If it is determined that the value of the variable N is a multiple of 4, it proceeds to Step S204 and a determination is made as to whether or not the time point that represents the variable AT is a time point that is between the time point a21 and the time point a22, in other words, a determination is made as to whether or not the time point that represents the variable AT exists in the temporal region that is delimited by the window W_3. If it is determined that it exists in the temporal region, it proceeds to Step S205, the first compression and expansion processing that is shown in FIG. 1 is executed with the third waveform data based on the pitch data P and the compression and

expansion data TR, it proceeds to Step S206, the value of the waveform data for which the compression and expansion processing was executed in Step S205 and the level of the window W_3 at the time point that represents the variable AT are matched and the output c is calculated. In the case where, in Step S203, it has been determined that the variable N is not a multiple of 4, and in the case where, in Step S204, it has been determined that the time point that represents the variable AT exists outside the temporal region that is delimited by the window W_3, the output c is made a value of "0."

Following that, the output b is calculated in Step S208 through Step S215.

First it proceeds to Step S208 and a determination is made as to whether or not the value of the control variable N is a multiple of 2. If it is determined that the value of the variable N is a multiple of 2, it proceeds to Step S209, filter processing is executed with the output c and the output cf is produced. Next, it proceeds to Step S210 and a determination is made as to whether or not the time point that represents the variable AT is a time point between the time point a11 and the time point a12, in other words, a determination is made as to whether or not the time point that represents the variable AT exists in the temporal region that is delimited by the window W_2. If it is determined that it exists in the temporal region that is delimited by the window W_2, it proceeds to Step S211, the third compression and expansion processing that is shown in FIG. 3 is executed with the second waveform data based on the pitch data P and the compression and expansion data TR, it proceeds to Step S212, the value of the waveform data for which the compression and expansion processing was executed in Step S211 and the level of the window W_2 at the time point that represents the variable AT are mated and the output bo is calculated. Next, it proceeds to Step S213, the output bo and the output cf are multiplied and the output b is calculated.

In the case, in Step S210, where it has been determined that the time point that represents the variable AT exists outside the temporal region that is delimited by the window W_2, it proceeds to Step S214 and the output bo becomes a value of "0." It then proceeds to Step S213 the output bo (here it is a value of "0") and the output cf are added and the output b is calculated.

In the case where, in Step S208, it has been determined that the value of the variable N is not a multiple of 2, it proceeds to Step S215 and the output b becomes a value of "0."

Following that, the output a is produced in Step S216 through Step S221.

First it proceeds to Step S216, filter processing is executed with the output b and the output a is produced. Next, it proceeds to Step S217 and a determination is made as to whether or not the time point that represents the variable AT is a time point that is between the time point a01 and the time point a02, in other words, a determination is made as to whether or not the time point that represents the variable AT exists in the temporal region that is delimited by the window W_1. If a determination is made that it exists in the temporal region that is delimited by the window W_1, it proceeds to Step S218 and the third compression and expansion processing is executed with the first waveform data based on the pitch data P and the compression and expansion data TR. It then proceeds to Step S219, the value of the waveform data for which the compression and expansion processing has been executed and the level of the window W_1 at the time point that represents the variable AT are matched and the output ao is calculated. Next, it proceeds to Step S220, the output ao and the output bf are added and the output a is calculated.

In the case where, in Step S217, it has been determined that the time point that represents the variable AT exists outside the temporal region that is delimited by the window W_1, it proceeds to Step S221 and the output ao becomes a value of "0." It then proceeds to Step S220, the output ao (here it is a value of "0") and the output bf are added and the output a is calculated.

Following that, it proceeds to Step S222 and the output a is output via the D/A converter 18 that is shown in FIG. 4.

Following that, in Step S223 through Step S225, it advances so that the value of the control variable N is cyclicly changed in the range of a value of "0" through a value of "3" and terminates.

Incidentally, in each of the preferred embodiments that have been discussed above, waveform data that express a multiple number of waveforms in which the original

waveform has been band divided have been input to a multiple number of compression and expansion means but, in the waveform compression and expansion apparatus of the present invention, it is also satisfactory if it is set up so that waveform data that express the original waveform are input to all of the multiple number of compression and expansion means.

In addition, in the second preferred embodiment that was discussed above, the specification of the compression and expansion formats is, in essence, carried out by the separation of the portions from the outputs of a multiple number of compression and expansion means that correspond to each of the multiple number of divided waveforms that comprise the original waveform which has been divided into a multiple number of temporal regions. However, the processing format specification means of the present invention may also be one in which a multiple number of divided waveforms are divided among and input to a multiple number of compression and expansion means.

Furthermore, in the second preferred embodiment that was discussed above, the compression and expansion processing formats of each of the compression and expansion means are fixed, however, in the waveform compression and expansion apparatus of the present invention, the compression and expansion processing formats of each of the compression and expansion means may be ones that change together with the passage of time.

What is claimed is:

1. A method for generating a compressed and expanded waveform from original waveform data, the method comprising the steps of:

frequency band-dividing the original waveform data to produce a plurality of frequency band-divided waveforms;

receiving position data including a plurality of time points indicating when waveform data is to be read out from the plurality of frequency band-divided waveforms, and position information elements indicating a particular location in the plurality of frequency band-divided waveforms corresponding to each time point;

generating at least one processed waveform from each frequency band-divided waveform according to the position data and at least one compression and expansion format; and

superimposing a plurality of processed waveforms generated from all frequency band-divided waveforms to form the compressed and expanded waveform.

2. A method as recited in claim 1, wherein in accordance with a first compression and expansion format, the step of generating at least one processed waveform from each frequency band-divided waveform further includes the steps of:

receiving a plurality of opening and starting addresses, each opening and starting address designating a starting point of cycles that comprise the frequency band-divided waveform;

receiving a plurality of position information elements, each position information element designating a particular cycle and address of the frequency band-divided waveform corresponding to each time point;

reading out first waveform data from the frequency band-divided waveform of approximately two repeated cycles starting at the opening and starting address associated with the cycle corresponding to every other time point, and waveshaping the first waveform data with an envelope to form a first processed waveform; and

reading out second waveform data from the frequency band-divided waveform of approximately two repeated cycles starting at the opening and starting address associated with the cycle corresponding to every other time point that does not coincide with the reading out of the first waveform data, and waveshaping the second waveform data with the envelope to form a second processed waveform.

3. A method as recited in claim 2, further including the step of repetitively reading out cycles within the first and second waveform data when a first interval between addresses designated by the plurality of position information elements is less than a second interval between addresses in the plurality of opening and starting addresses.

4. A method as recited in claim 2, further including the step of jump reading out cycles within the first and second waveform data when a first interval between addresses designated by the plurality of position information elements is greater than a second interval between addresses in the plurality of opening and starting addresses.

5. A method as recited in claim 1, wherein in accordance with a second compression and expansion format, the step of generating at least one processed waveform from each frequency band-divided waveform further includes the steps of:

receiving a plurality of position information elements, each position information element designating a different address of the frequency band-divided waveform corresponding to each time point;

receiving pitch data indicating a read-out speed of the waveform portions;

reading out successive first waveform portions from the frequency band-divided waveform at the read-out speed at every other time point, each first waveform portion comprising waveform data starting at the address of the position information element corresponding to the time point, the successive first waveform portions comprising first read-out waveform data;

reading out successive second waveform portions from the frequency band-divided waveform at the read-out speed at every other time point that does not coincide with the reading out of successive first waveform portions, each second waveform portion comprising waveform data starting at the address of the position information element corresponding to the time point, the successive second waveform portions comprising second read-out waveform data;

waveshaping the first read-out waveform data with an envelope to form a first processed waveform; and

waveshaping the second read-out waveform data with the envelope to form a second processed waveform.

6. A method as recited in claim 5, further including the step of repetitively reading out first and second waveform portions when each read-out start point associated with each position information element is earlier in time than the time point corresponding to the position information element.

7. A method as recited in claim 5, further including the step of jump reading out first and second waveform portions when each read-out start point associated with each position information element is later in time than the time point corresponding to the position information element.

8. A method as recited in claim 1, wherein in accordance with a third compression and expansion format, the step of generating at least one processed waveform from each frequency band-divided waveform further includes the steps of:

receiving a plurality of mark addresses that designate a starting point at zero-crossings of waveform segments of the frequency band-divided waveform;

receiving a plurality of position information elements indicating a particular waveform segment of the frequency band-divided waveform corresponding to each time point;

receiving pitch data indicating a read-out speed of the waveform portions;

reading out portions of at least one waveform segment at the read-out speed at every time point of the frequency band-divided waveform, the portions of at least one waveform segment comprising waveform data starting at the mark address associated with the waveform segment corresponding to the time point; and

sequencing consecutive portions of at least one waveform segment to generate a processed waveform from the frequency band-divided waveform.

9. A method as recited in claim 8, further including the step of repetitively reading out portions of at least one waveform segment when a first interval between addresses designated by the plurality of position information elements is less than a second interval between addresses in the plurality of mark addresses.

10. A method as recited in claim 8, further including the step of jump reading out portions of at least one waveform segment when a first interval between addresses designated by the plurality of position information elements is greater than a second interval between addresses in the plurality of mark addresses.

11. A method as recited in claim 1, further including the step of compressing or expanding each processed waveform by an identical amount of time.

12. A method as recited in claim 11, the step of frequency band-dividing the original waveform data further including the steps of:

sampling the original waveform data at a sampling frequency F_S; and

dividing the original waveform data into N frequency band-divided waveforms, wherein the Mth frequency band-divided waveform, where M is an integer varying from one to N, is sampled at a sampling frequency equal to F_S divided by $2^{(M-1)}$, and has a frequency band ranging from F_S divided by $2^{(M+1)}$ to F_S divided by $2^{(M)}$.

13. A method as recited in claim 12, the step of superimposing a plurality of processed waveforms comprising the steps of:

filtering at least one of the N processed waveforms generated from the N frequency band-divided waveforms according to the frequency band of the frequency band-divided waveform associated with each processed waveform; and

summing the N processed waveforms to form the compressed and expanded waveforms.

14. A method as recited in claim 13, the step of frequency band-dividing the original waveform data further including the steps of:

dividing the original waveform data into three frequency band-divided waveforms;

generating at least one processed waveform from the first frequency band-divided waveform in accordance with a second compression and expansion format comprising the steps of

receiving a plurality of position information elements, each position information element designating a different address of the frequency band-divided waveform corresponding to each time point,

receiving pitch data indicating a read-out speed of the waveform portions,

reading out successive first waveform portions from the frequency band-divided waveform at the read-out speed at every other time point, each first waveform portion comprising waveform data starting at the address of the position information element corresponding to the time point, the successive first waveform portions comprising first read-out waveform data,

reading out successive second waveform portions from the frequency band-divided waveform at the read-out speed at every other time point that does not coincide with the reading out of successive first waveform portions, each second waveform portion comprising waveform data starting at the address of the position information element corresponding to the time point, the successive second waveform portions comprising second read-out waveform data,

waveshaping the first read-out waveform data with an envelope to form a first processed waveform, and

waveshaping the second read-out waveform data with the envelope to form a second processed waveform; and

generating at least one processed waveform from the second and third frequency band-divided waveforms in accordance with a third compression and expansion format comprising the steps of

receiving a plurality of mark addresses that designate a starting point at zero-crossings of waveform segments of the frequency band-divided waveform,

receiving a plurality of position information elements indicating a particular waveform segment of the frequency band-divided waveform corresponding to each time point,

receiving pitch data indicating a read-out speed of the waveform portions,

reading out portions of at least one waveform segment at the read-out speed at every time point of the frequency band-divided waveform, the portions of at least one waveform segment comprising waveform data starting at the mark address associated with the waveform segment corresponding to the time point, and

sequencing consecutive portions of at least one waveform segment to generate a processed waveform from the frequency band-divided waveform.

15. A method as recited in claim 14, the step of superimposing a plurality of processed waveforms further including the steps of:

sampling and low-pass filtering the processed waveform generated from the third frequency band-divided waveform according to the sampling frequency associated with the second frequency band-divided waveform and frequency band associated with the third frequency band-divided waveform to generate a third intermediate processed waveform;

summing the third intermediate processed waveform with the at least one processed waveform generated from the second frequency band-divided waveform to generate a second intermediate processed waveform;

sampling and low-pass filtering the second intermediate processed waveform according to the sampling frequency associated with the first frequency band-divided waveform and frequency band associated with the second and third frequency band-divided waveforms to generate a first intermediate processed waveform; and

summing the first intermediate processed waveform with the at least one processed waveform generated from the first frequency band-divided waveform to form the compressed and expanded waveform.

16. A method as recited in claim 1, the step of frequency band-dividing the original waveform data further including the steps of:

dividing the original waveform data into a plurality of frequency band-divided waveforms, each frequency band-divided waveform having a plurality of frequency band waveform components.

17. A method as recited in claim 16, the step of superimposing a plurality of processed waveforms comprising the steps of:

multiplying each processed waveform with a level-controllable time window;

filtering at least one of the plurality of processed waveforms generated from the plurality of frequency band-divided waveforms according to a frequency band of the frequency band-divided waveform associated with each processed waveform; and

summing the processed waveforms to form the compressed and expanded waveforms.

18. A method as recited in claim 17, the step of frequency band-dividing the original waveform data further including the steps of:

dividing the original waveform data into three frequency band-divided waveforms;

generating at least one processed waveform from the first and second frequency band-divided waveforms in accordance with a third compression and expansion format comprising the steps of

receiving a plurality of mark addresses that designate a starting point at zero-crossings of waveform segments of the frequency band-divided waveform,

receiving a plurality of position information elements indicating a particular waveform segment of the frequency band-divided waveform corresponding to each time point,

receiving pitch data indicating a read-out speed of the waveform portions,

reading out portions of at least one waveform segment at the read-out speed at every time point of the frequency band-divided waveform, the portions of at least one waveform segment comprising waveform data

starting at the mark address associated with the waveform segment corresponding to the time point, and

sequencing consecutive portions of at least one waveform segment to generate a processed waveform from the frequency band-divided waveform; and

generating at least one processed waveform from the third frequency band-divided waveform in accordance with a first compression and expansion format comprising the steps of

receiving a plurality of opening and starting addresses, each opening and starting address designating a starting point of cycles that comprise the frequency band-divided waveform,

receiving a plurality of position information elements, each position information element designating a particular cycle and address of the frequency band-divided waveform corresponding to each time point,

reading out first waveform data from the frequency band-divided waveform of approximately two repeated cycles starting at the opening and starting address associated with the cycle corresponding to every other time point, and waveshaping the first waveform data with an envelope to form a first processed waveform, and

reading out second waveform data from the frequency band-divided waveform of approximately two repeated cycles starting at the opening and starting address associated with the cycle corresponding to every other time point that does not coincide with the reading out of the first waveform data, and waveshaping the second waveform data with the envelope to form a second processed waveform.

19. A method as recited in claim 18, the step of superimposing a plurality of processed waveforms further including the steps of:

sampling and low-pass filtering the processed waveform generated from the third frequency band-divided waveform according to the sampling frequency associated with the second frequency band-divided waveform and frequency band associated with the third frequency band-divided waveform to generate a third intermediate processed waveform;

summing the third intermediate processed waveform with the at least one processed waveform generated from the second frequency band-divided waveform to generate a second intermediate processed waveform;

sampling and low-pass filtering the second intermediate processed waveform according to the sampling frequency associated with the first frequency band-divided waveform and frequency band associated with the second and third frequency band-divided waveforms to generate a first intermediate processed waveform; and

summing the first intermediate processed waveform with the at least one processed waveform generated from the first frequency band-divided waveform to form the compressed and expanded waveform.

20. A method as recited in claim 19, the step of superimposing a plurality of processed waveforms further including the step of establishing the time windows to produce cross-fading.

21. A method for generating a compressed and expanded waveform from original waveform data, the method comprising the steps of:

receiving position data including a plurality of time points indicating when waveform data is to be read out from the original waveform data, and position information elements indicating a particular location in the original waveform data corresponding to each time point;

generating at least one processed waveform from the original waveform data according to the position data and at least one compression and expansion format; and

superimposing a plurality of processed waveforms generated from the original waveform data to form the compressed and expanded waveform.

22. A system for generating a compressed and expanded waveform from original waveform data, the system comprising:

an input device for receiving position data including a plurality of time points and position information elements; and

a processor including memory programmed for frequency band-dividing the original waveform data to produce a plurality of frequency band-divided waveforms, generating at least one processed waveform from each frequency band-divided waveform according to the position data and at least one compression and expansion format, and superimposing a plurality of processed waveforms generated from all frequency band-divided waveforms to form the compressed and expanded waveform.

23. A waveform compression and expansion apparatus for compressing and expanding a plurality of frequency band-divided waveforms generated from an original waveform, the plurality of frequency band-divided waveforms comprising waveform components of a plurality of frequency bands, the apparatus comprising:

compression and expansion means with which the plurality of frequency band-divided waveforms are apportioned to at least two kinds of compression and expansion formats and each of the plurality of frequency band-divided waveforms are compressed and expanded in a direction of a temporal axis by an identical amount; and

a superimposing means in which, by superimposing the plurality of compressed and expanded frequency band-divided waveforms, an original waveform that has been compressed or expanded in the direction of the temporal axis is formed.

24. An apparatus as recited in claim 23, wherein the compression and expansion means executes compression and expansion processing with a processing period that is as long as the frequency band-divided waveform which possesses the waveform component of a low frequency band in the plurality of frequency band-divided waveforms, and forms compressed and expanded waveforms that correspond to the frequency band-divided waveforms.

25. A waveform compression and expansion apparatus for compressing and expanding a plurality of temporally divided waveforms, comprising:

a processing format specification means in which one compression and expansion processing format from a plurality of mutually different compression and expansion processing formats is specified for each of the plurality of temporally divided waveforms; and

a compression and expansion means in which compression and expansion processing is performed on each temporally divided waveform to compress or

expand the temporally divided waveform in a direction of a temporal axis according to the specified compression and expansion format.

6650734 052505.0

ABSTRACT

With the goal of presenting a waveform compression and expansion apparatus with which the sound quality of such things as musical tones that are expressed by waveforms is satisfactory following the compression and expansion of the waveforms of the musical tones etc., a method and system for waveform compression and expansion is disclosed in which all of the multiple number of band divided waveforms that comprise the original waveform which has been band divided are apportioned to at least two kinds of compression and expansion formats and form a multiple number of compressed and expanded waveforms by compression or expansion an identical amount only in the direction of the temporal axis.

Sony Ref: 5959546

6660217 5995860

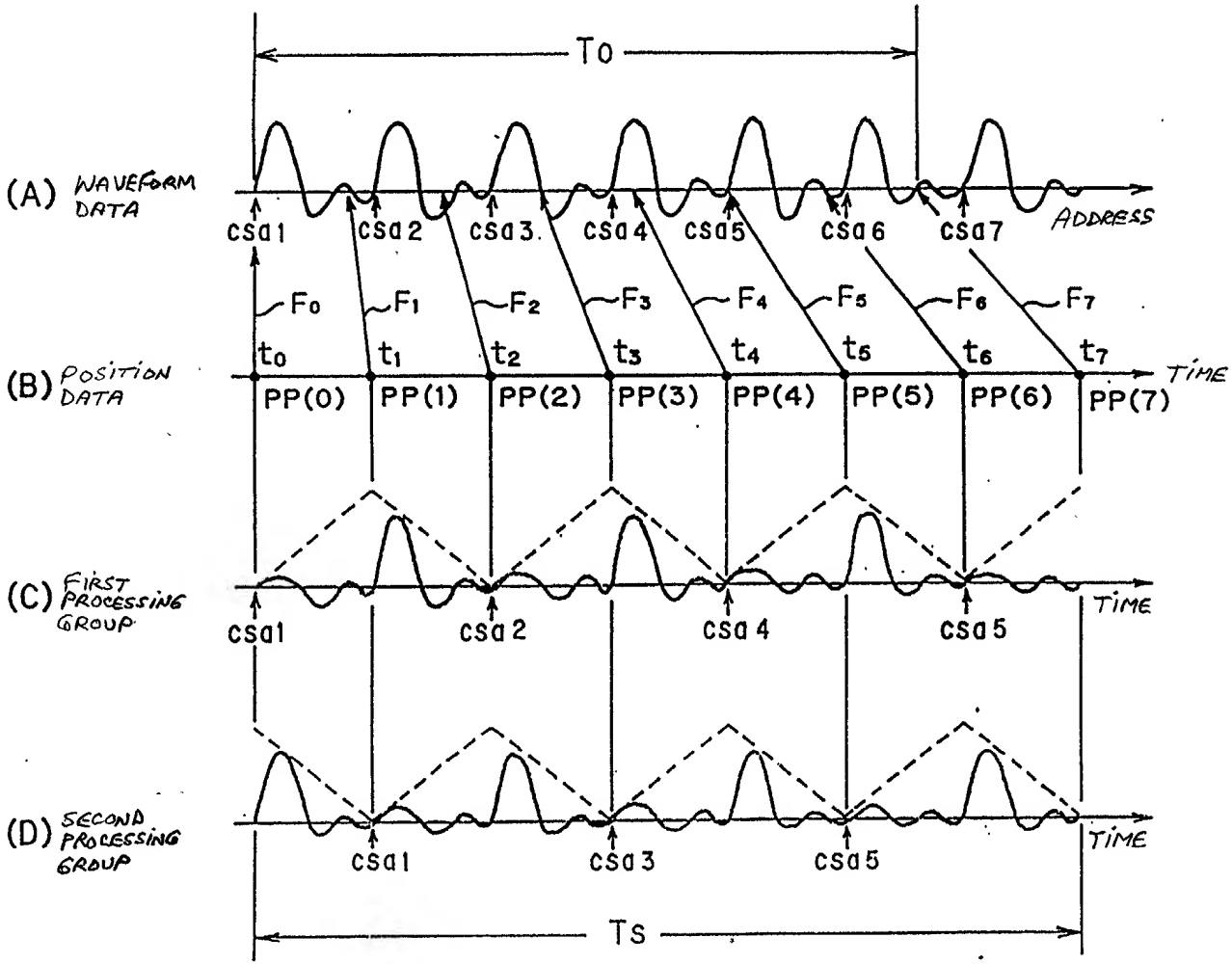

Fig. 1

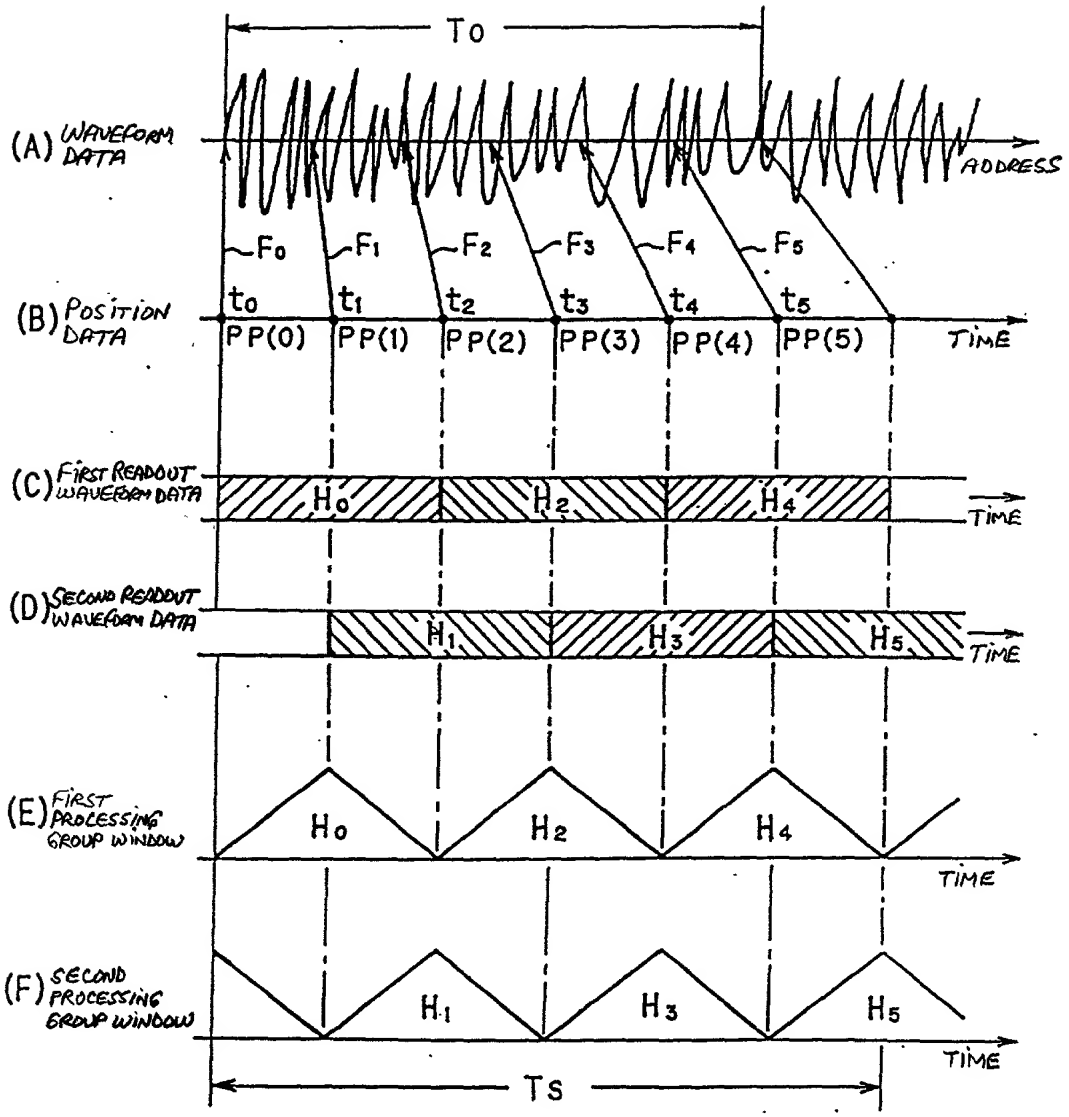
To
(A) WAVEFORM DATA
ADDRESS
Fo
F1
F2
F3
F4
F5
(B) POSITION DATA
to
t1
t2
t3
t4
t5
PP(0)
PP(1)
PP(2)
PP(3)
PP(4)
PP(5)
TIME
(C) FIRST READOUT WAVEFORM DATA
Ho
H2
H4
TIME
(D) SECOND READOUT WAVEFORM DATA
H1
H3
H5
TIME
(E) FIRST PROCESSING GROUP WINDOW
Ho
H2
H4
TIME
(F) SECOND PROCESSING GROUP WINDOW
H1
H3
H5
TIME
Ts

Fig. 2

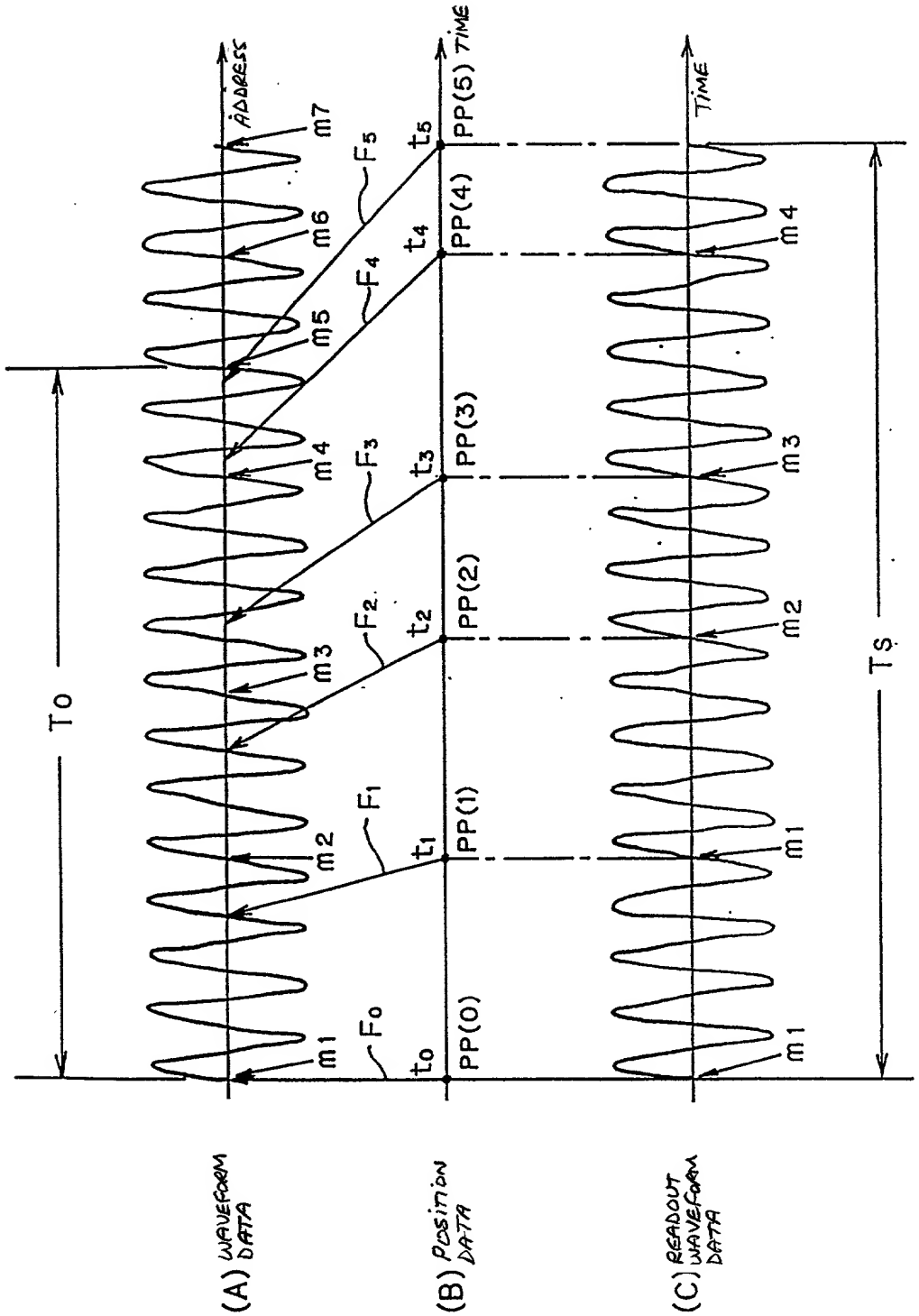
(A) WAVEFORM DATA
(B) POSITION DATA
(C) READOUT WAVEFORM DATA
ADDRESS
TIME
TIME
To
Ts
m1
m2
m3
m4
m5
m6
m7
Fo
F1
F2
F3
F4
F5
to
t1
t2
t3
t4
t5
PP(0)
PP(1)
PP(2)
PP(3)
PP(4)
PP(5)

Fig.3

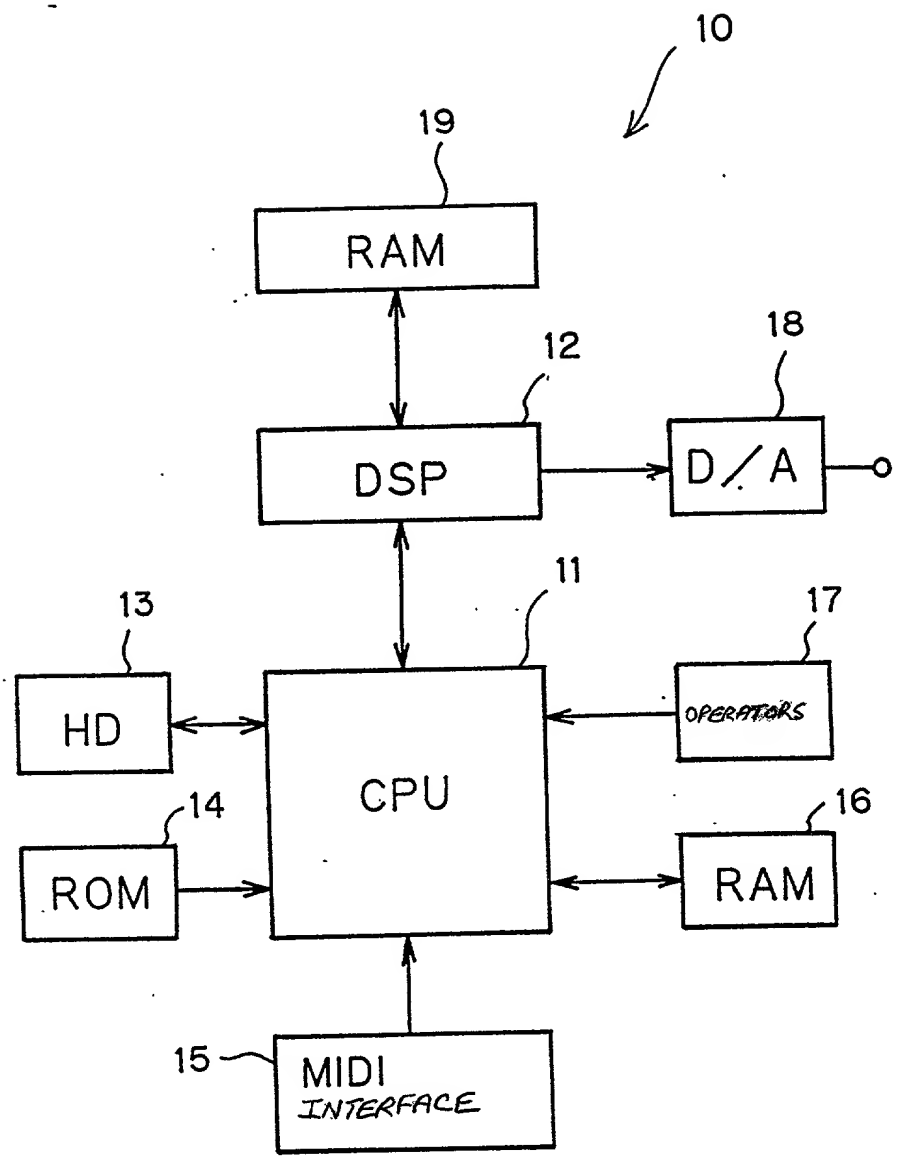
10
19
RAM
12
18
DSP
D/A
11
13
17
HD
OPERATORS
CPU
14
16
ROM
RAM
15
MIDI
INTERFACE

Fig.4

6660271 5999548b0

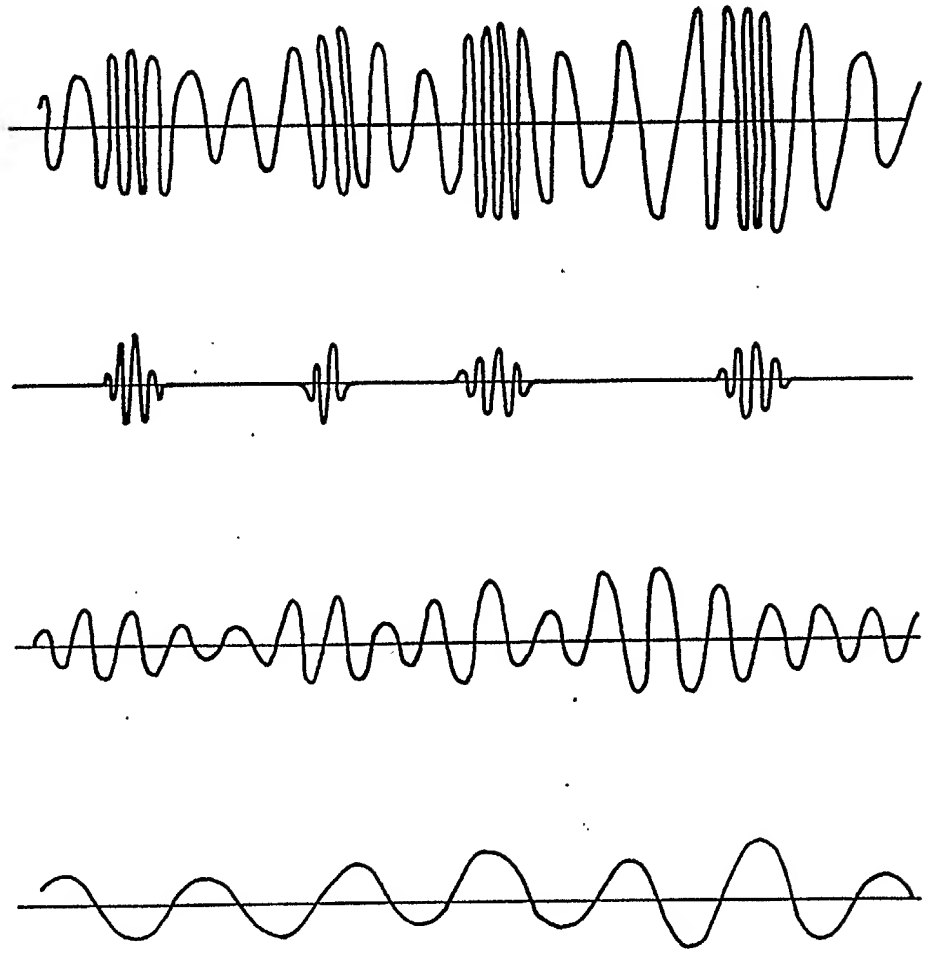

Fig. 5

0960274 5050540

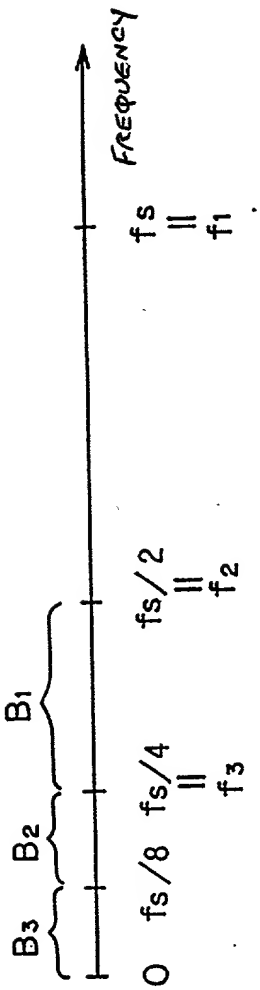

Fig. 6

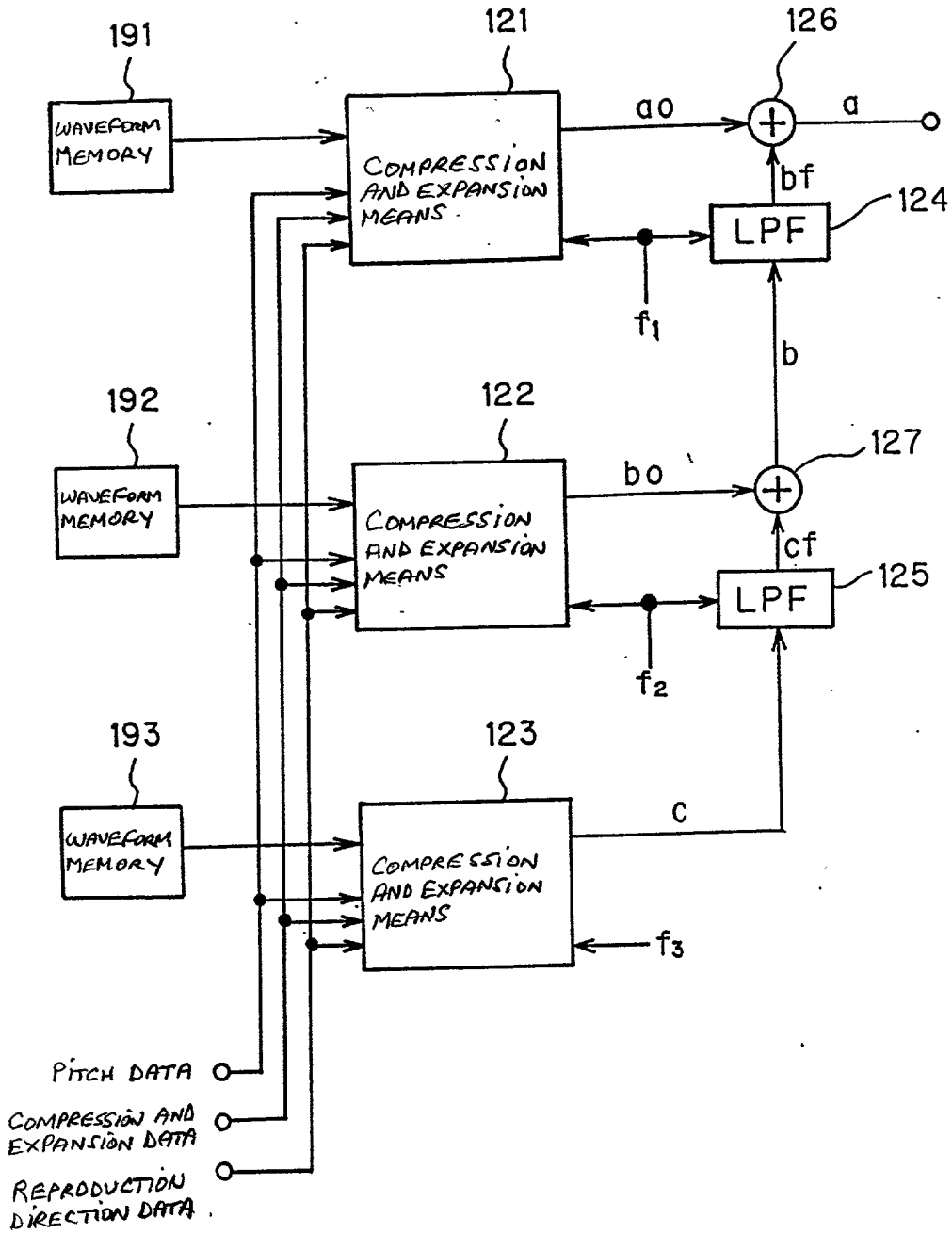
191
WAVEFORM MEMORY
121
COMPRESSION AND EXPANSION MEANS
126
ao
a
bf
124
LPF
f1
b
192
WAVEFORM MEMORY
122
COMPRESSION AND EXPANSION MEANS
bo
127
cf
125
LPF
f2
193
WAVEFORM MEMORY
123
COMPRESSION AND EXPANSION MEANS
c
f3
PITCH DATA
COMPRESSION AND EXPANSION DATA
REPRODUCTION DIRECTION DATA

Fig. 7

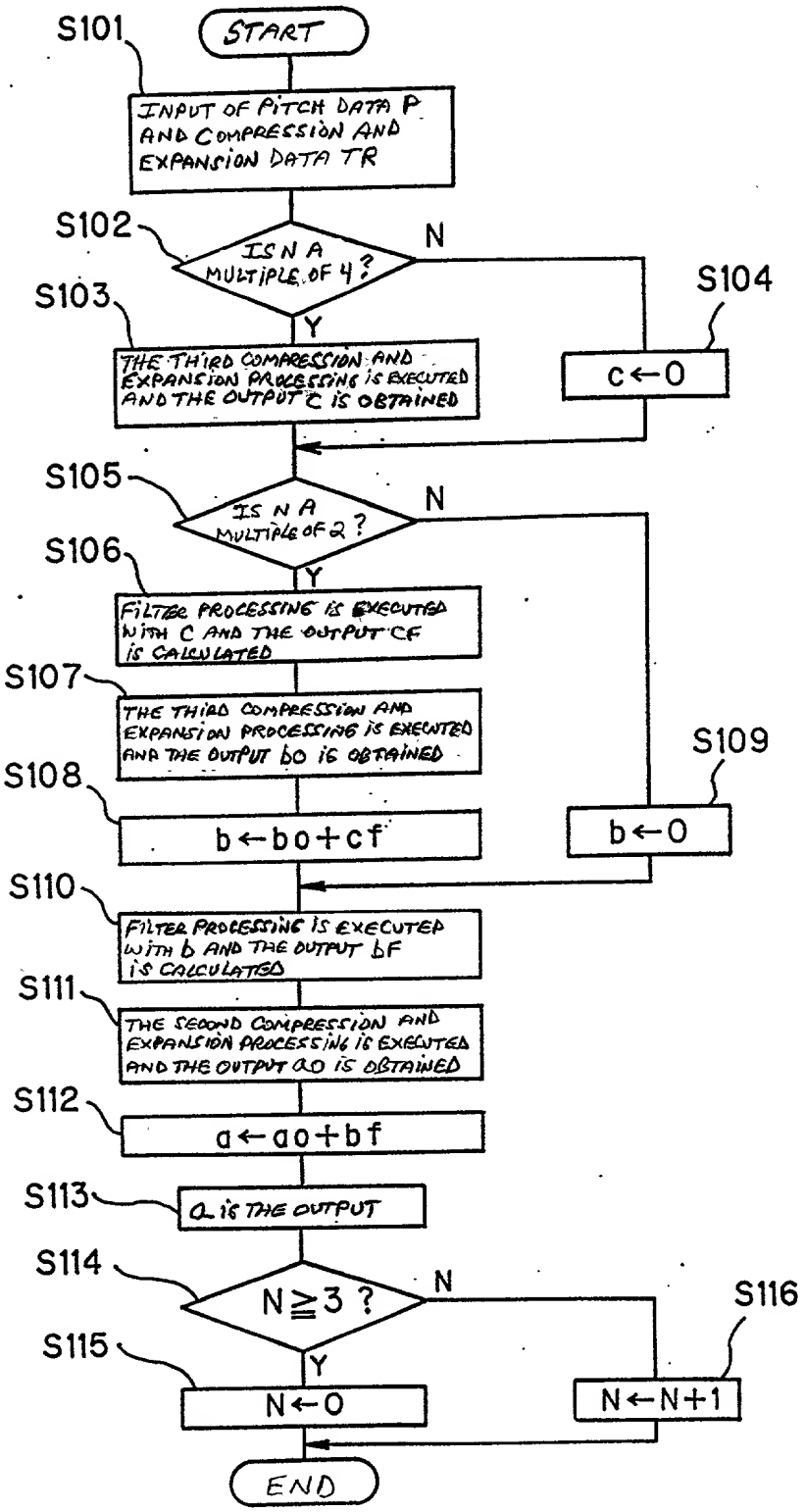
S101
START
INPUT OF PITCH DATA P AND COMPRESSION AND EXPANSION DATA TR
S102
IS N A MULTIPLE OF 4?
N
Y
S103
THE THIRD COMPRESSION AND EXPANSION PROCESSING IS EXECUTED AND THE OUTPUT C IS OBTAINED
S104
c←0
S105
IS N A MULTIPLE OF 2?
N
Y
S106
FILTER PROCESSING IS EXECUTED WITH C AND THE OUTPUT CF IS CALCULATED
S107
THE THIRD COMPRESSION AND EXPANSION PROCESSING IS EXECUTED AND THE OUTPUT bo IS OBTAINED
S108
b←bo+cf
S109
b←0
S110
FILTER PROCESSING IS EXECUTED WITH b AND THE OUTPUT bF IS CALCULATED
S111
THE SECOND COMPRESSION AND EXPANSION PROCESSING IS EXECUTED AND THE OUTPUT ao IS OBTAINED
S112
a←ao+bf
S113
a IS THE OUTPUT
S114
N≧3?
N
Y
S115
N←0
S116
N←N+1
END

Fig. 8

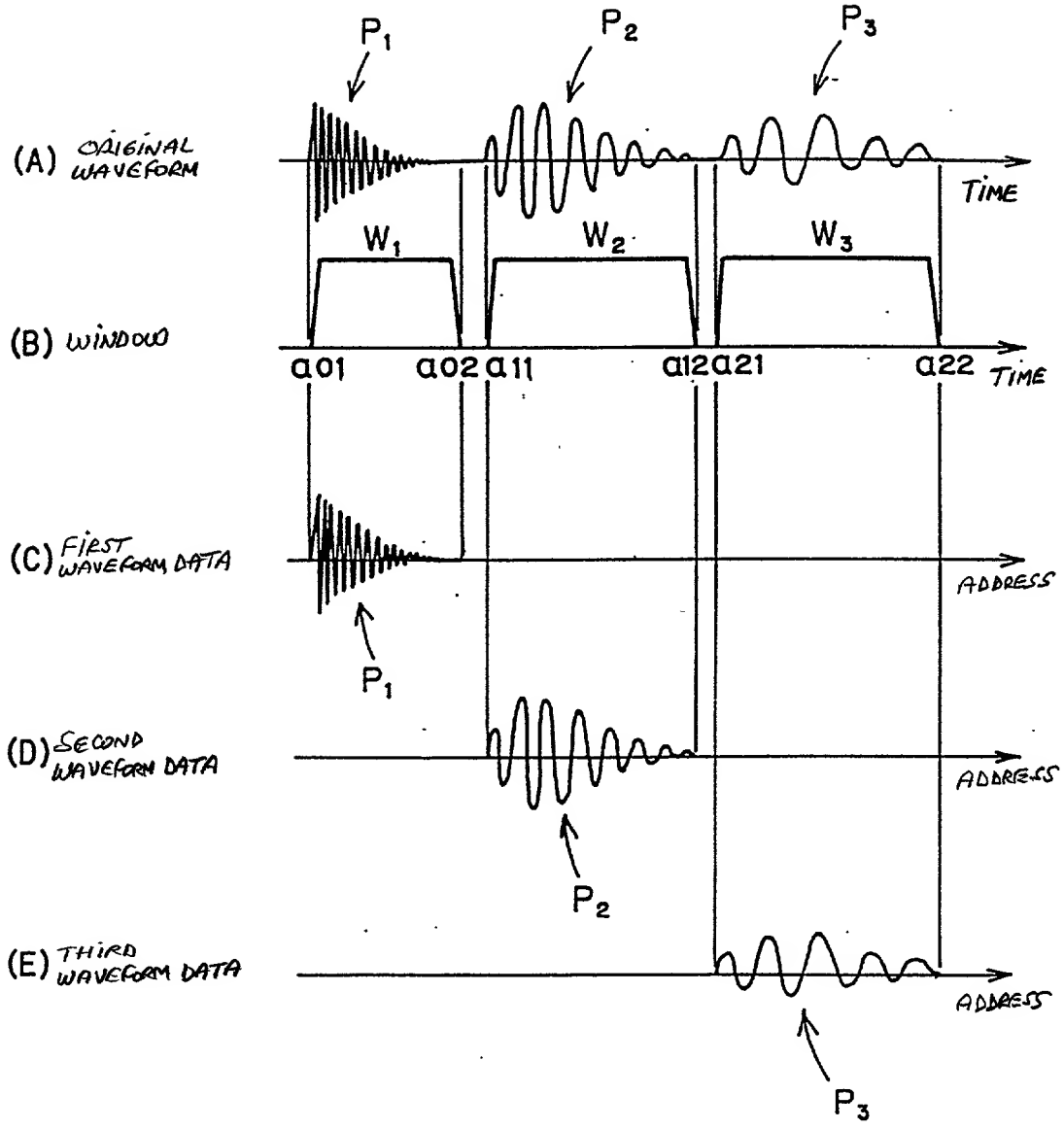
P1
P2
P3
(A) ORIGINAL WAVEFORM
TIME
W1
W2
W3
(B) WINDOW
a01
a02
a11
a12
a21
a22
TIME
(C) FIRST WAVEFORM DATA
ADDRESS
P1
(D) SECOND WAVEFORM DATA
ADDRESS
P2
(E) THIRD WAVEFORM DATA
ADDRESS
P3

Fig. 9

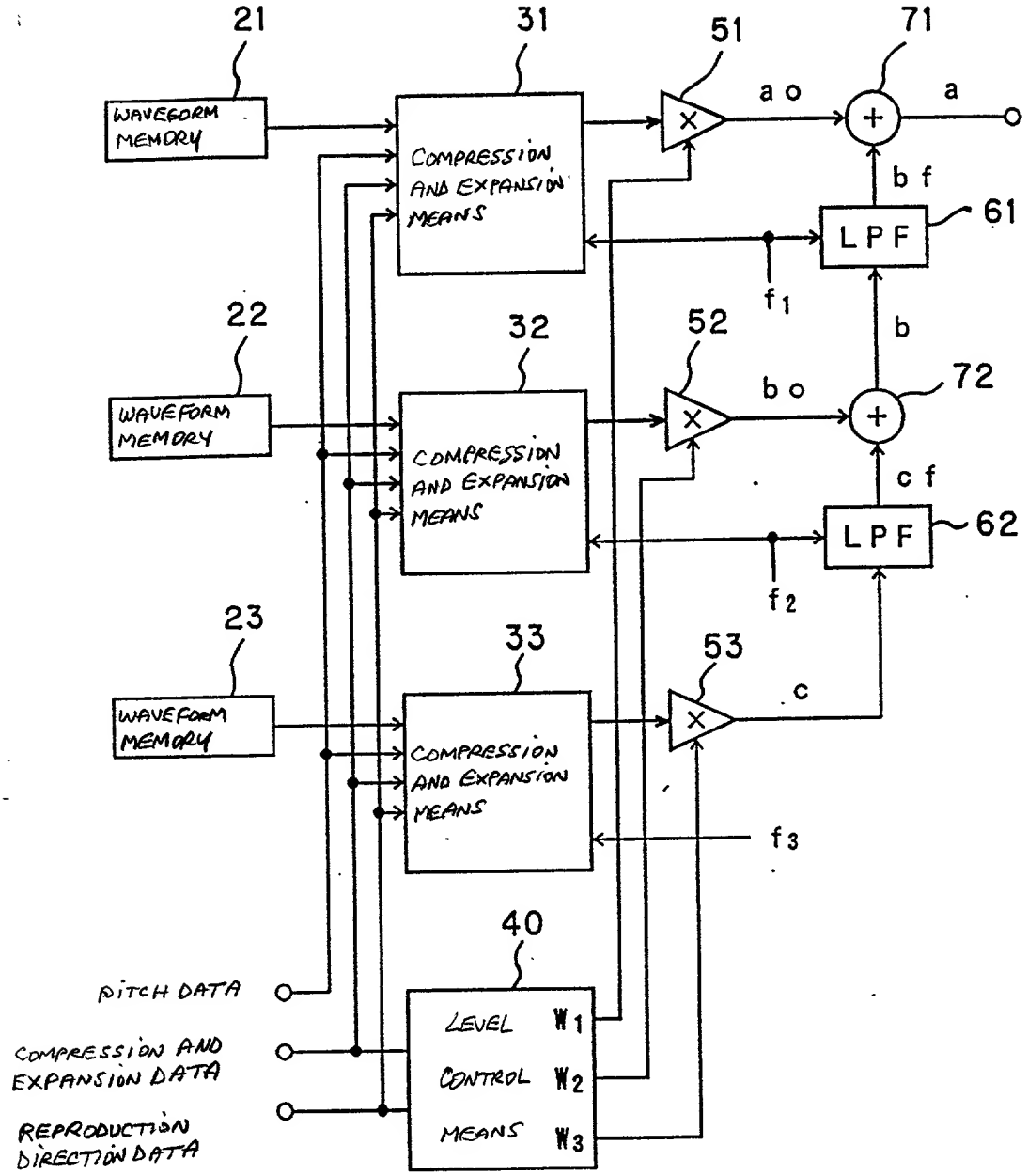
21
31
51
71
WAVEFORM MEMORY
COMPRESSION AND EXPANSION MEANS
X
a o
+
a
b f
61
LPF
f1
22
32
52
b
WAVEFORM MEMORY
COMPRESSION AND EXPANSION MEANS
X
b o
+
72
c f
LPF
62
f2
23
33
53
c
WAVEFORM MEMORY
COMPRESSION AND EXPANSION MEANS
X
f3
40
PITCH DATA
COMPRESSION AND EXPANSION DATA
REPRODUCTION DIRECTION DATA
LEVEL CONTROL MEANS
W1
W2
W3

Fig.10

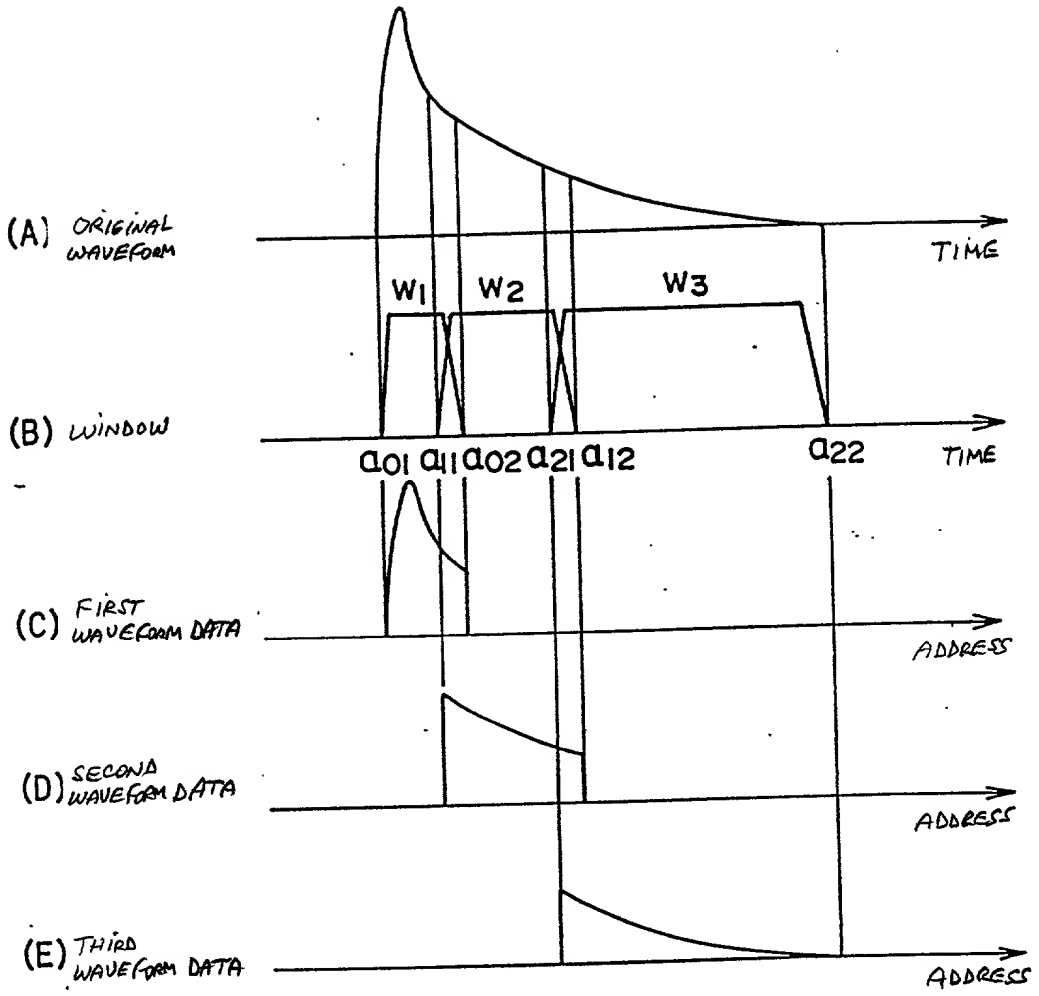
(A) ORIGINAL WAVEFORM
TIME
W1
W2
W3
(B) WINDOW
a01 a11 a02 a21 a12
a22
TIME
(C) FIRST WAVEFORM DATA
ADDRESS
(D) SECOND WAVEFORM DATA
ADDRESS
(E) THIRD WAVEFORM DATA
ADDRESS

Fig. 11

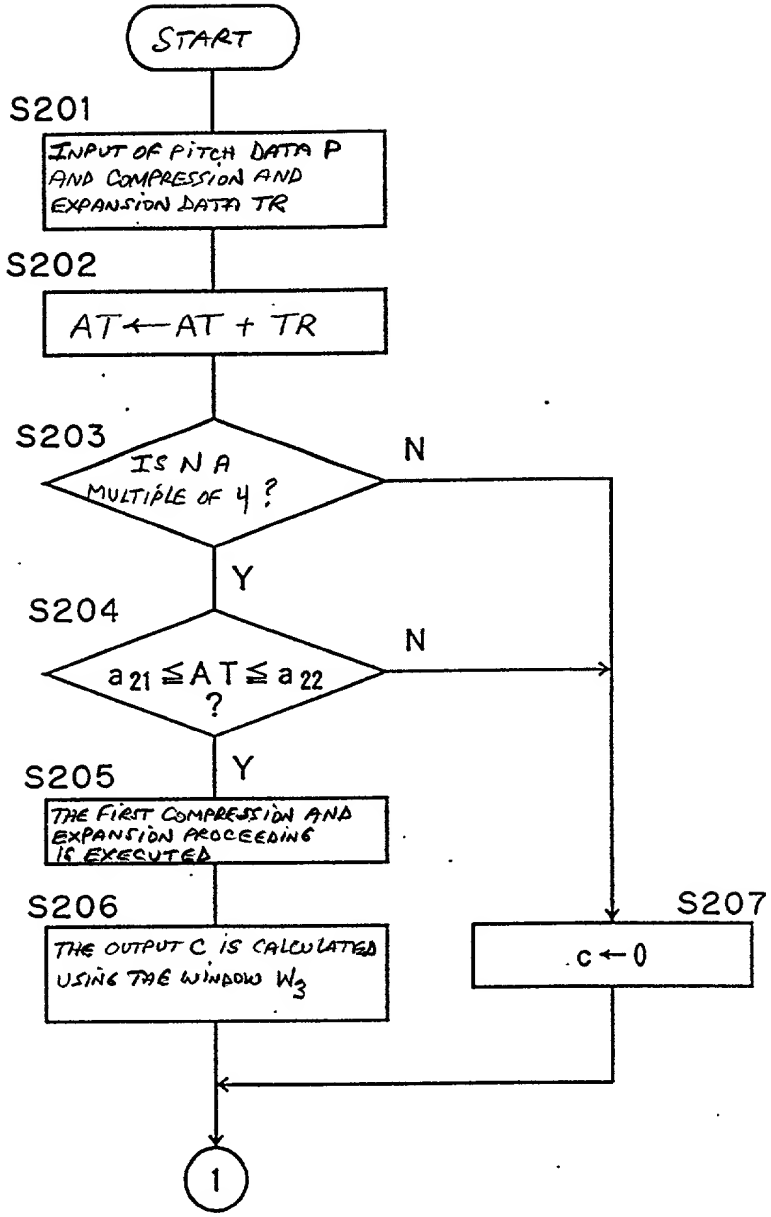
START
S201
INPUT OF PITCH DATA P AND COMPRESSION AND EXPANSION DATA TR
S202
AT ← AT + TR
S203
IS N A MULTIPLE OF 4 ?
N
Y
S204
a21 ≦ AT ≦ a22 ?
N
Y
S205
THE FIRST COMPRESSION AND EXPANSION PROCEEDING IS EXECUTED
S206
THE OUTPUT C IS CALCULATED USING THE WINDOW W3
S207
c ← 0
1

Fig.12

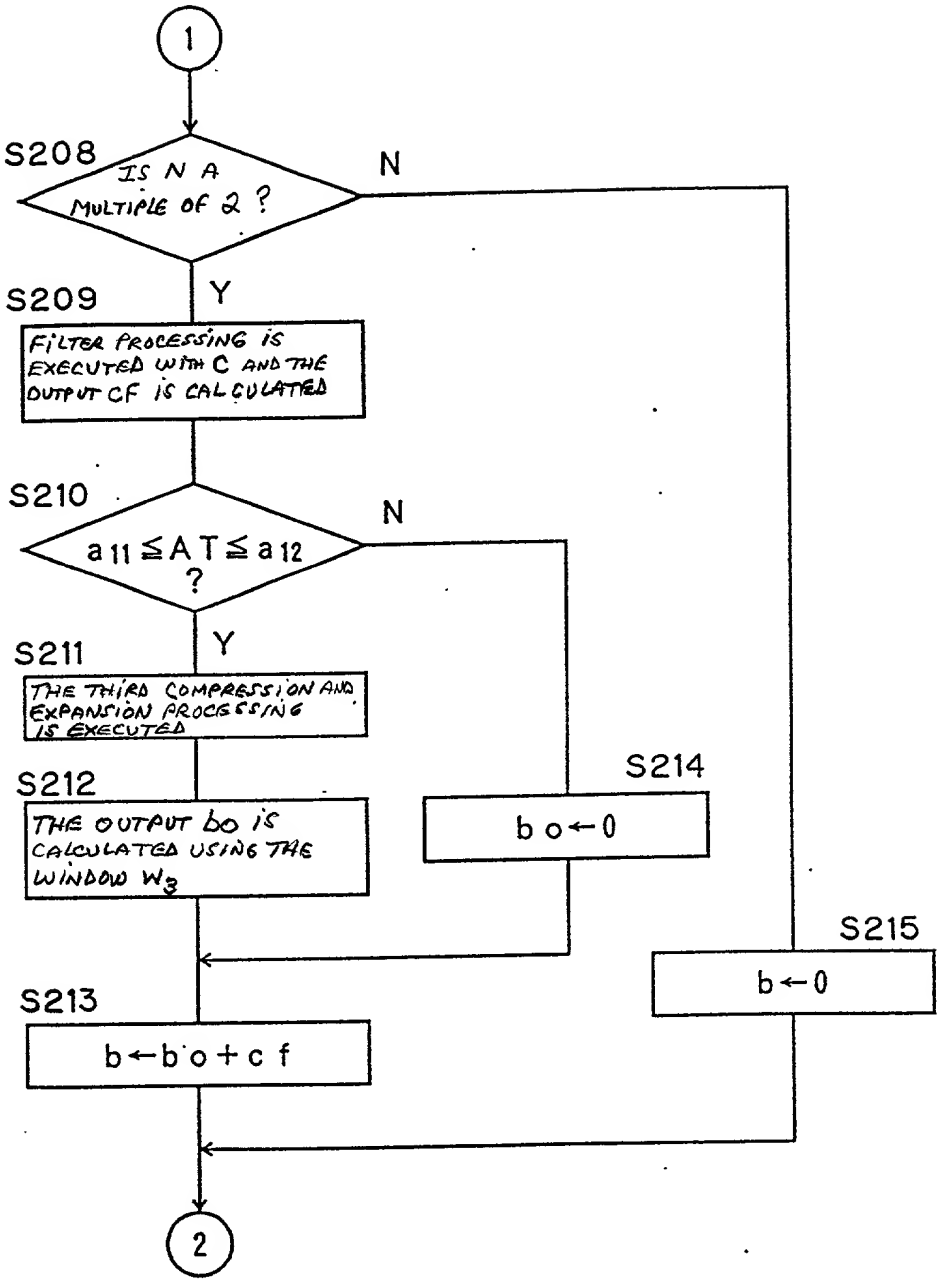
1
S208
IS N A MULTIPLE OF 2 ?
N
Y
S209
FILTER PROCESSING IS EXECUTED WITH C AND THE OUTPUT CF IS CALCULATED
S210
a 11 ≦ A T ≦ a 12 ?
N
Y
S211
THE THIRD COMPRESSION AND EXPANSION PROCESSING IS EXECUTED
S212
THE OUTPUT bo IS CALCULATED USING THE WINDOW W3
S214
b o ← 0
S215
b ← 0
S213
b ← b o + c f
2

Fig.13

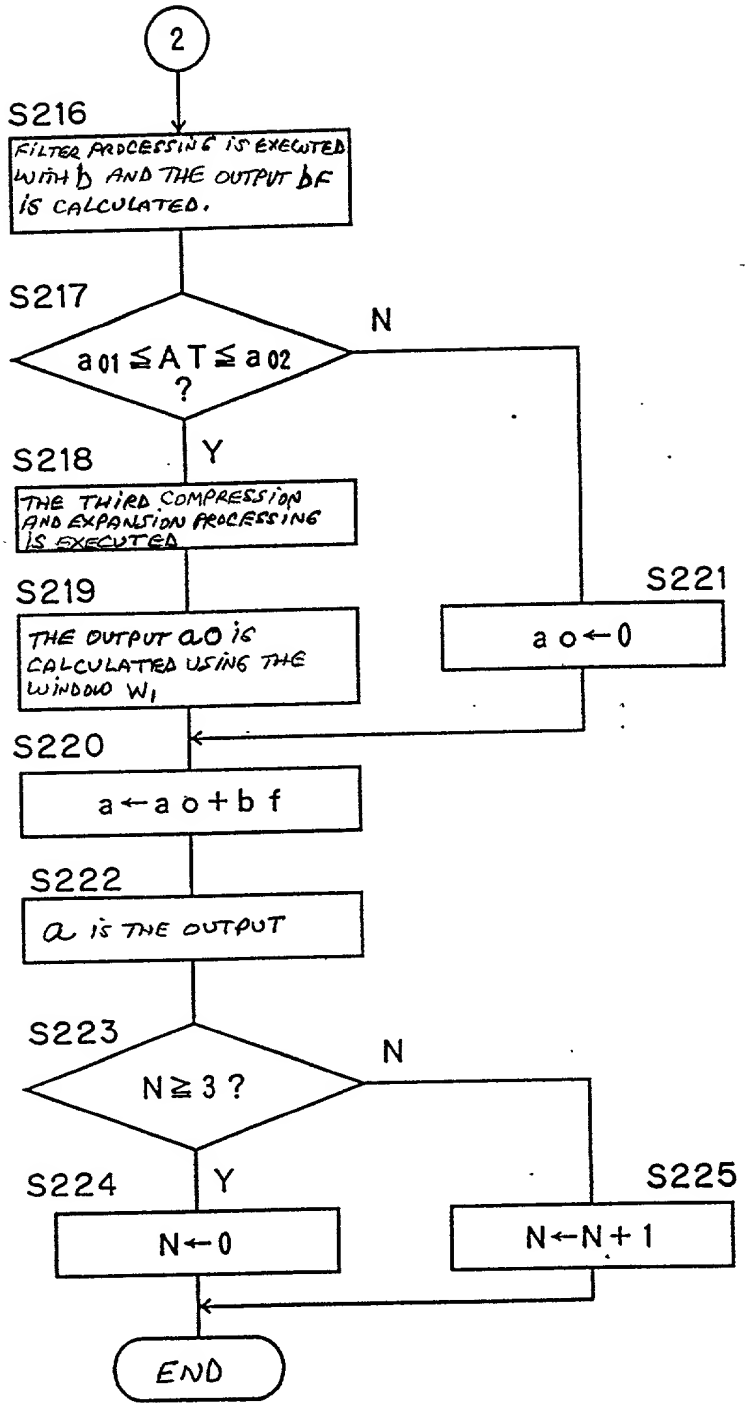
2
S216
FILTER PROCESSING IS EXECUTED WITH b AND THE OUTPUT bf IS CALCULATED.
S217
a01 ≦ AT ≦ a02 ?
N
Y
S218
THE THIRD COMPRESSION AND EXPANSION PROCESSING IS EXECUTED
S219
THE OUTPUT a0 IS CALCULATED USING THE WINDOW W1
S221
a0 ← 0
S220
a ← a0 + bf
S222
a IS THE OUTPUT
S223
N ≧ 3 ?
N
Y
S224
N ← 0
S225
N ← N + 1
END

Fig. 14

PTO/SB/106 (8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD AND SYSTEM FOR WAVEFORM COMPRESSION AND EXPANSION

上記発明の明細書（下記の欄でx印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ __月__日に提出され、米国出願番号または特許協定条約国際出願番号を_____とし、
（該当する場合）_____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner of Patents and Trademarks, Washington, DC 20231.

PTO/SB/106 (8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Japanese Language Declaration
(日本語宣言書)

私は、米国法典第３５編１１９条(a)-(d)項又は３６５条(b)項に基き下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約３６５(a)項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
			☐
			☐

私は、第３５編米国法典１１９条(e)項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第３５編１２０条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約３６５条(c)に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第３５編１１２条第１項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第３７編１条５６項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第１８編第１００１条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

PTO/SB/106 (8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Japanese Language Declaration
(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*

書類送付先

Send Correspondence to:

Ted R. Rittmaster
FOLEY & LARDNER
2029 Century Park East, Suite 3500
Los Angeles, CA 90067-3021

直接電話連絡先： （名前及び電話番号）

Direct Telephone Calls to: *(name and telephone number)*

Ted R. Rittmaster
(310) 277-2223

唯一または第一発明者名	Full name of sole or first inventor Tadao Kikumoto
発明者の署名 日付	Inventor's signature Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address
第二共同発明者	Full name of second joint inventor, if any
第二共同発明者 日付	Second inventor's signature Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address

（第三以降の共同発明者についても同様に記載し、署名をすること）

(Supply similar information and signature for third and subsequent joint inventors.)